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Spielman et al.

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(54) **TRANSPORTATION ROUTE PLANNING AND GENERATION**

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G01C 21/34 (2006.01)

(52) **U.S. Cl.**
CPC ***G01C 21/3423*** (2013.01); ***G01C 21/3469*** (2013.01); ***G01C 21/3484*** (2013.01)

(58) **Field of Classification Search**
CPC G01C 21/3423; G01C 21/3469; G01C 21/3484
See application file for complete search history.

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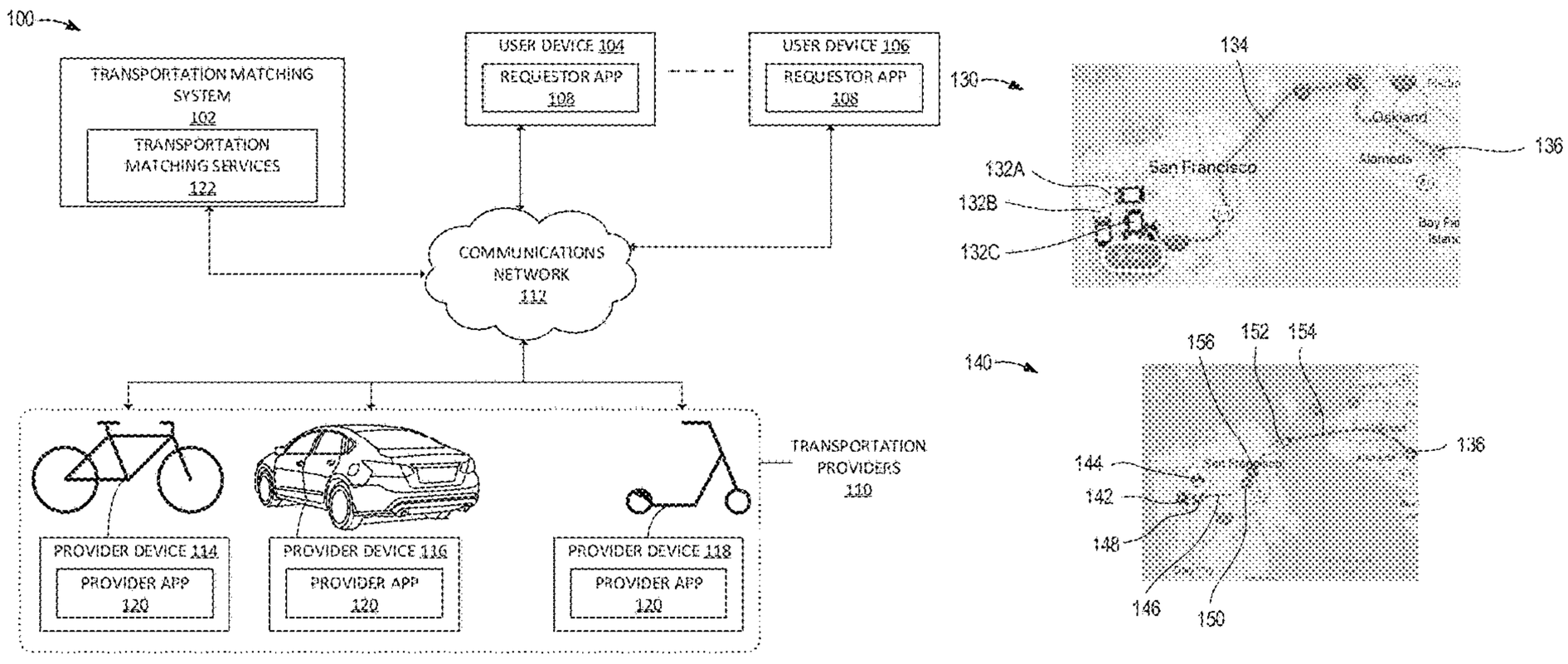
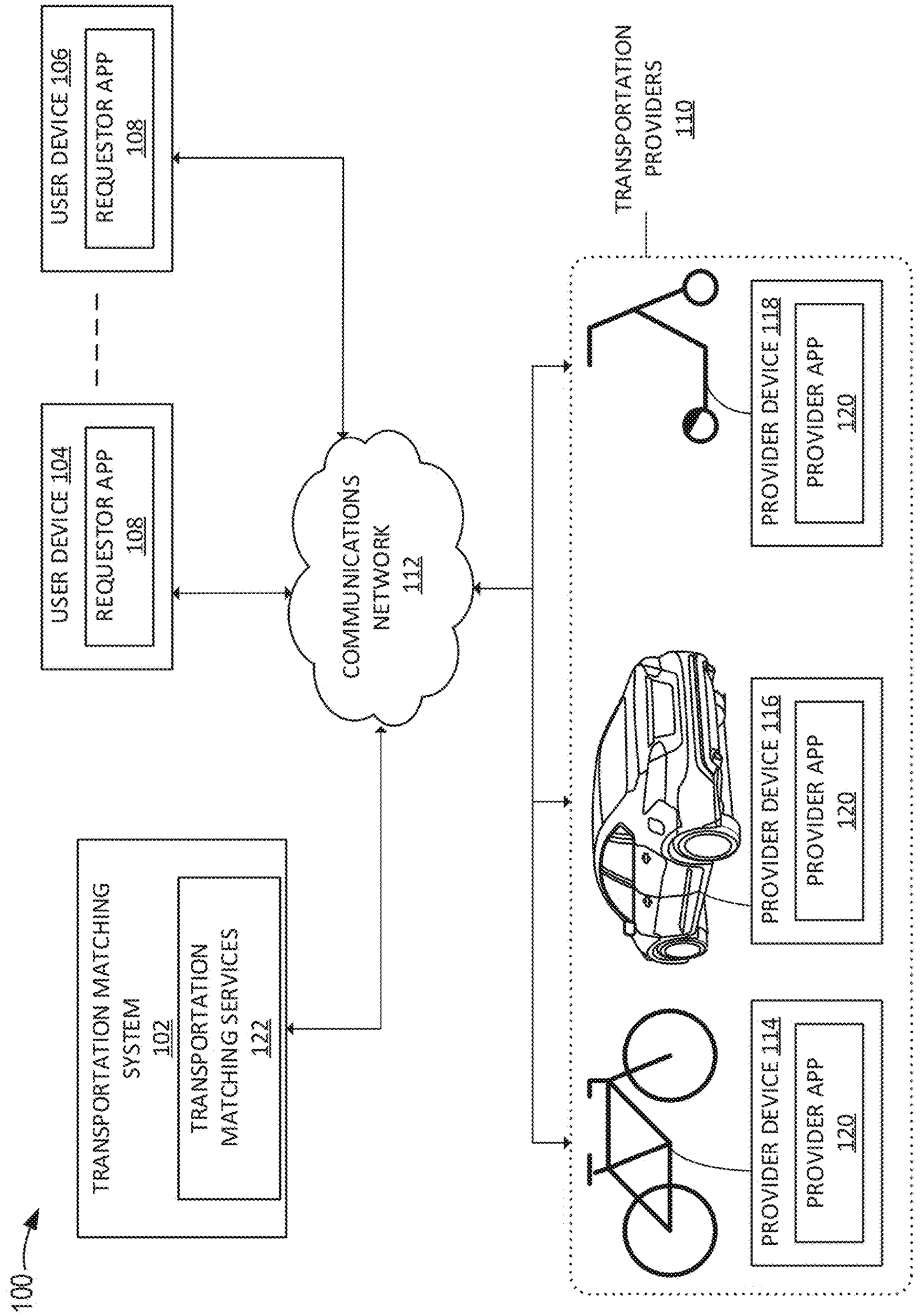
(74) *Attorney, Agent, or Firm* — Keller Jolley Preece

(57) **ABSTRACT**

Methods and systems for planning and creating transportation routes with multiple modalities are provided. In one embodiment, a method is provided that includes receiving a transportation request that includes a first location and a second location. A transportation proposal may then be generated including a route for transportation between the first location and the second location. The method may then include determining modalities available to provide transportation and determining respective transportation segments for the modalities, and at least a subset of the transportation segments may be combined to form the route for transportation. The transportation proposal, including the route for transportation, may then be transmitted for display on a mobile device.

20 Claims, 14 Drawing Sheets

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TRANSPORTATION MATCHING SYSTEM 102
TRANSPORTATION MATCHING SERVICES 122
COMMUNICATIONS NETWORK 112
USER DEVICE 104
REQUESTOR APP 108
USER DEVICE 106
REQUESTOR APP 108
TRANSPORTATION PROVIDERS 110
PROVIDER DEVICE 118
PROVIDER APP 120
PROVIDER DEVICE 116
PROVIDER APP 120
PROVIDER DEVICE 114
PROVIDER APP 120

FIG. 1A

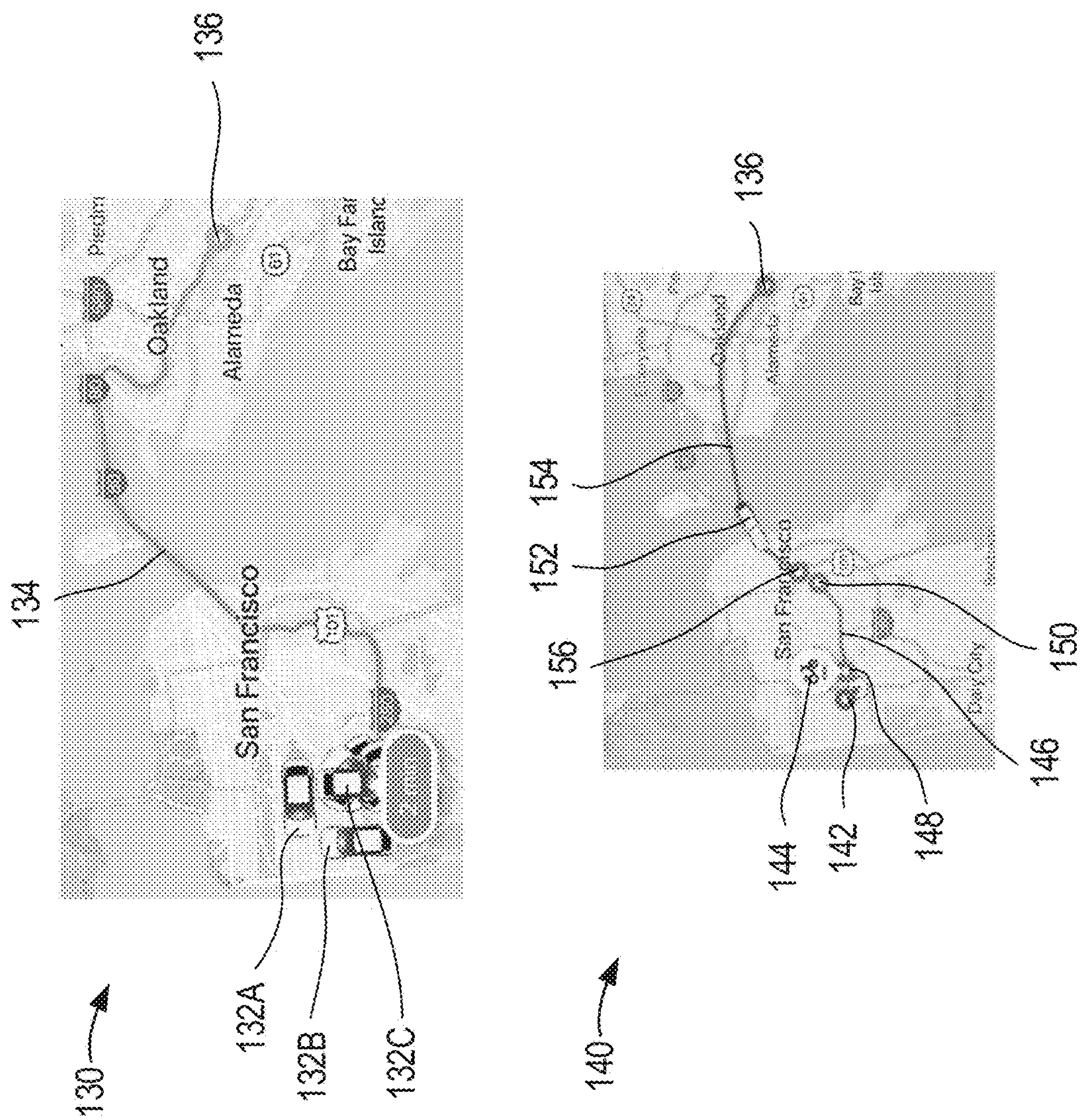

130
132A
132B
132C
134
136
San Francisco
Oakland
Alameda
140
136
154
152
156
150
146
148
142
144

FIG. 1B

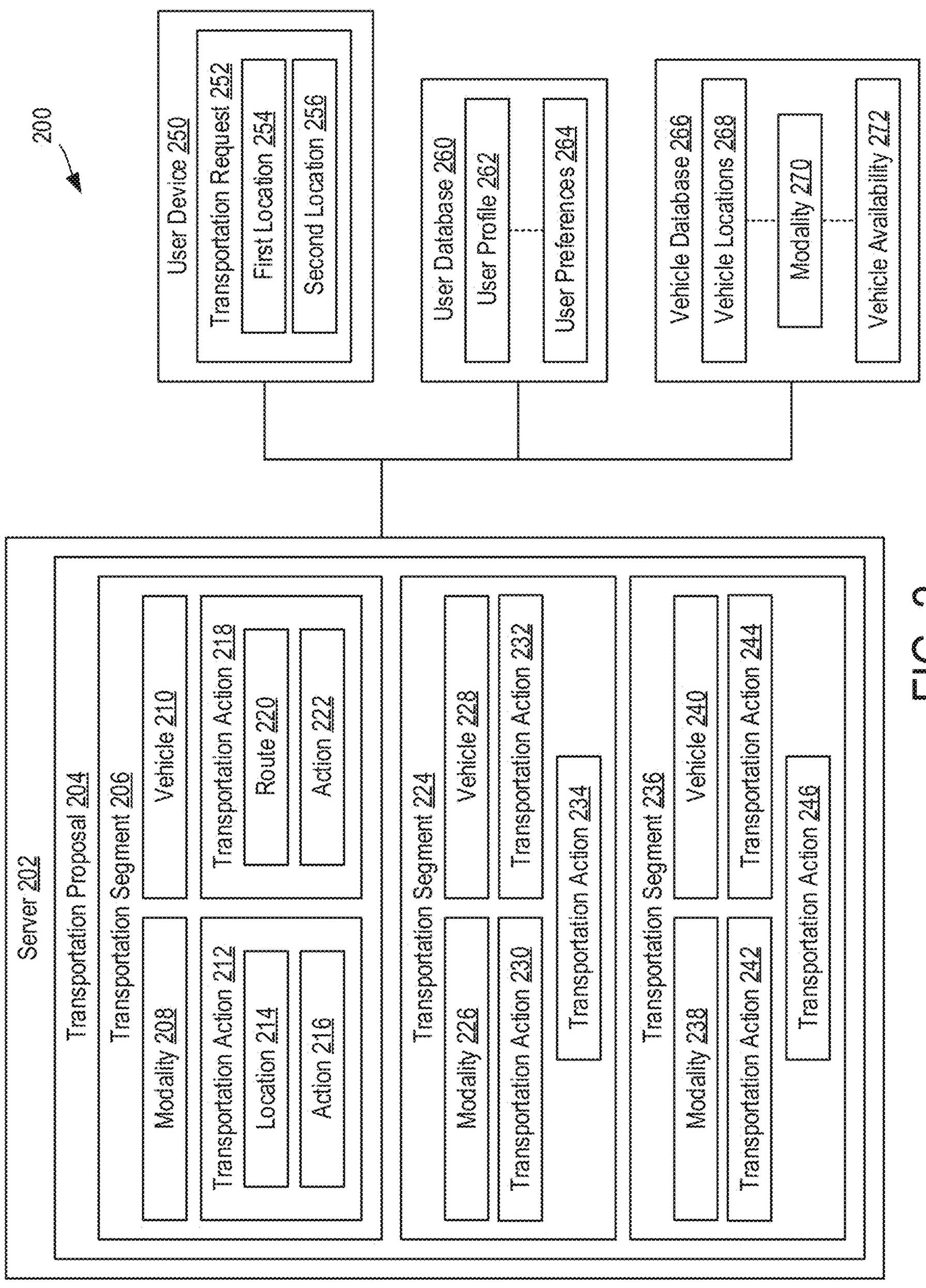
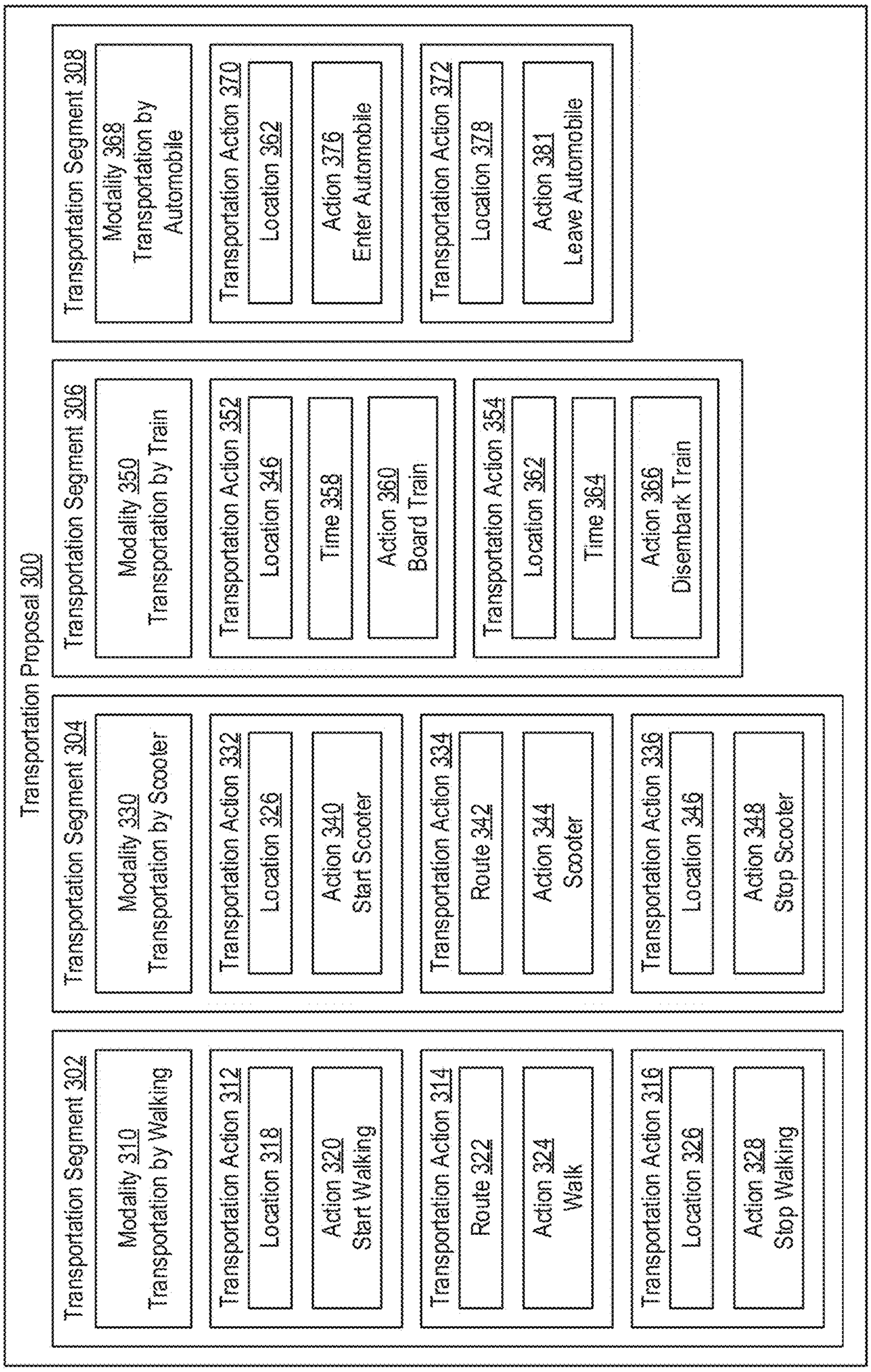

200
User Device 250
Transportation Request 252
First Location 254
Second Location 256
User Database 260
User Profile 262
User Preferences 264
Vehicle Database 266
Vehicle Locations 268
Modality 270
Vehicle Availability 272
Server 202
Transportation Proposal 204
Transportation Segment 206
Vehicle 210
Transportation Action 218
Route 220
Action 222
Modality 208
Transportation Action 212
Location 214
Action 216
Transportation Segment 224
Vehicle 228
Transportation Action 232
Transportation Action 234
Modality 226
Transportation Action 230
Transportation Segment 236
Vehicle 240
Transportation Action 244
Transportation Action 246
Modality 238
Transportation Action 242

FIG. 2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Transportation Segment 302
Modality 310
Transportation by Walking
Transportation Action 312
Location 318
Action 320
Start Walking
Transportation Action 314
Route 322
Action 324
Walk
Transportation Action 316
Location 326
Action 328
Stop Walking
Transportation Segment 304
Modality 330
Transportation by Scooter
Transportation Action 332
Location 326
Action 340
Start Scooter
Transportation Action 334
Route 342
Action 344
Scooter
Transportation Action 336
Location 346
Action 348
Stop Scooter
Transportation Segment 306
Modality 350
Transportation by Train
Transportation Action 352
Location 346
Time 358
Action 360
Board Train
Transportation Action 354
Location 362
Time 364
Action 366
Disembark Train
Transportation Segment 308
Modality 368
Transportation by Automobile
Transportation Action 370
Location 362
Action 376
Enter Automobile
Transportation Action 372
Location 378
Action 381
Leave Automobile

FIG. 3A

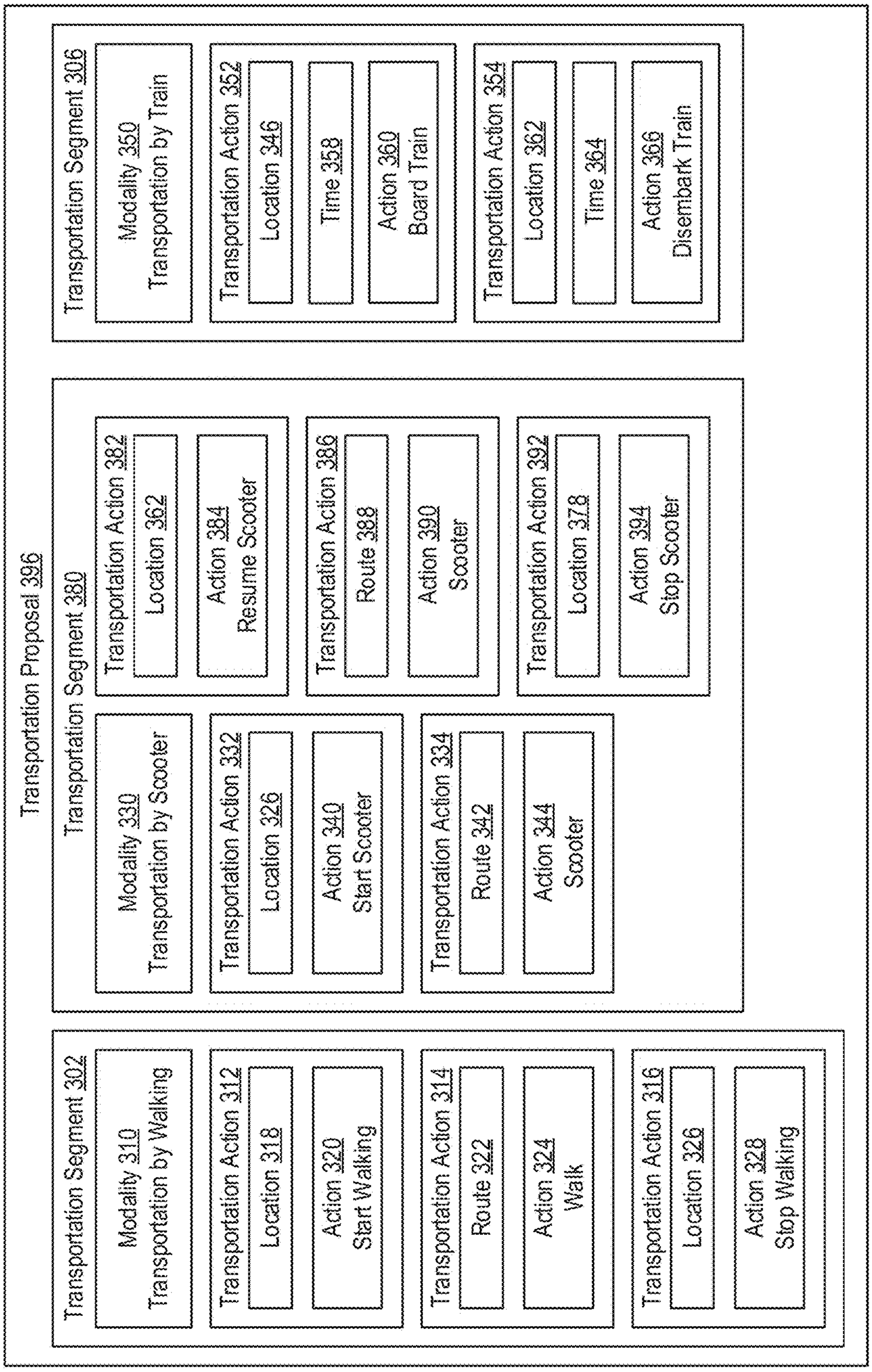
Transportation Proposal 396
Transportation Segment 306
Modality 350
Transportation by Train
Transportation Action 352
Location 346
Time 358
Action 360
Board Train
Transportation Action 354
Location 362
Time 364
Action 366
Disembark Train
Transportation Segment 380
Modality 330
Transportation by Scooter
Transportation Action 332
Location 326
Action 340
Start Scooter
Transportation Action 334
Route 342
Action 344
Scooter
Transportation Action 382
Location 362
Action 384
Resume Scooter
Transportation Action 386
Route 388
Action 390
Scooter
Transportation Action 392
Location 378
Action 394
Stop Scooter
Transportation Segment 302
Modality 310
Transportation by Walking
Transportation Action 312
Location 318
Action 320
Start Walking
Transportation Action 314
Route 322
Action 324
Walk
Transportation Action 316
Location 326
Action 328
Stop Walking

FIG. 3B

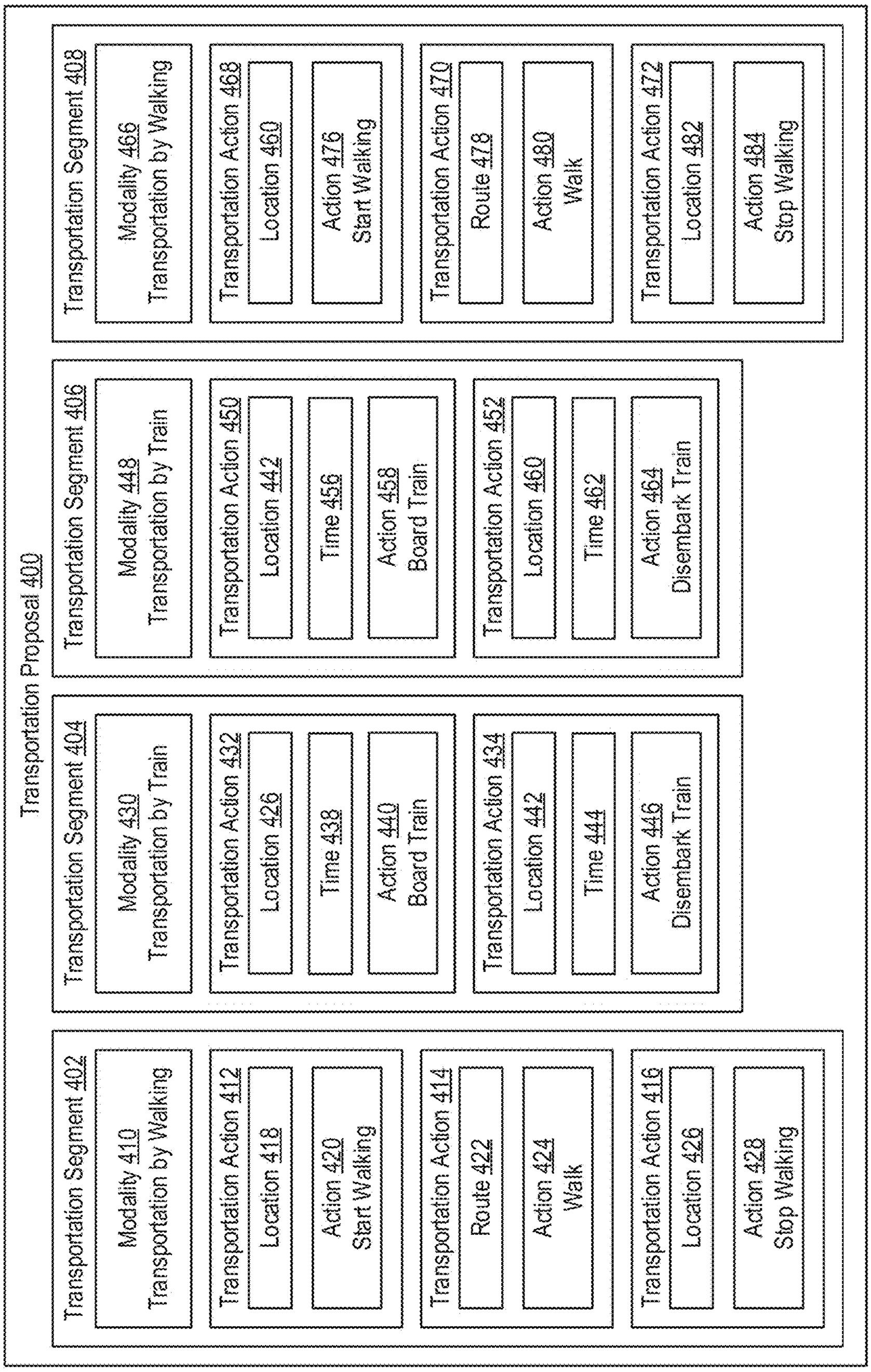
Transportation Proposal 400
Transportation Segment 402
Modality 410
Transportation by Walking
Transportation Action 412
Location 418
Action 420
Start Walking
Transportation Action 414
Route 422
Action 424
Walk
Transportation Action 416
Location 426
Action 428
Stop Walking
Transportation Segment 404
Modality 430
Transportation by Train
Transportation Action 432
Location 426
Time 438
Action 440
Board Train
Transportation Action 434
Location 442
Time 444
Action 446
Disembark Train
Transportation Segment 406
Modality 448
Transportation by Train
Transportation Action 450
Location 442
Time 456
Action 458
Board Train
Transportation Action 452
Location 460
Time 462
Action 464
Disembark Train
Transportation Segment 408
Modality 466
Transportation by Walking
Transportation Action 468
Location 460
Action 476
Start Walking
Transportation Action 470
Route 478
Action 480
Walk
Transportation Action 472
Location 482
Action 484
Stop Walking

FIG. 4A

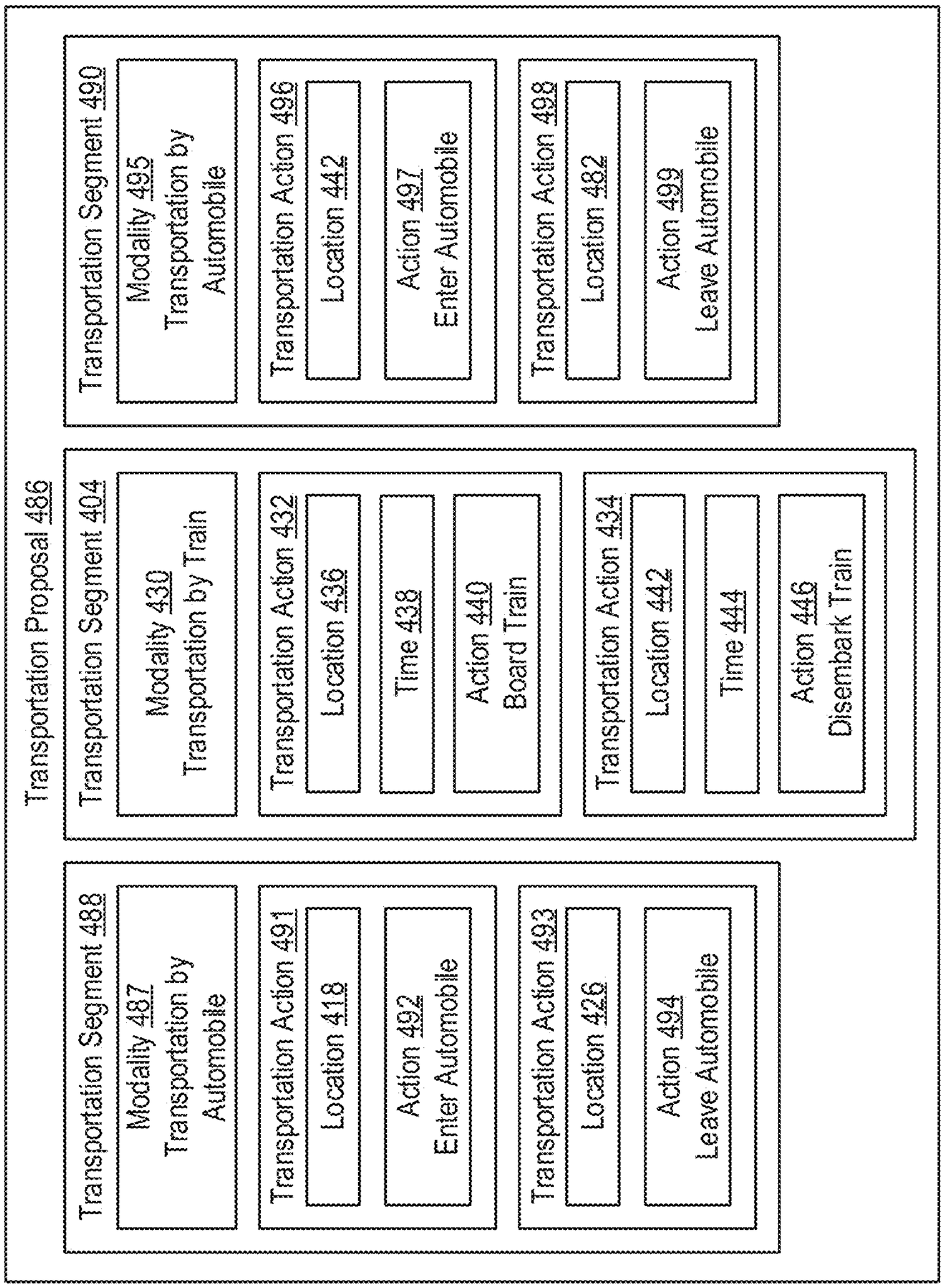
Transportation Proposal 486
Transportation Segment 404
Modality 430
Transportation by Train
Transportation Action 432
Location 436
Time 438
Action 440
Board Train
Transportation Action 434
Location 442
Time 444
Action 446
Disembark Train
Transportation Segment 488
Modality 487
Transportation by Automobile
Transportation Action 491
Location 418
Action 492
Enter Automobile
Transportation Action 493
Location 426
Action 494
Leave Automobile
Transportation Segment 490
Modality 495
Transportation by Automobile
Transportation Action 496
Location 442
Action 497
Enter Automobile
Transportation Action 498
Location 482
Action 499
Leave Automobile

FIG. 4B

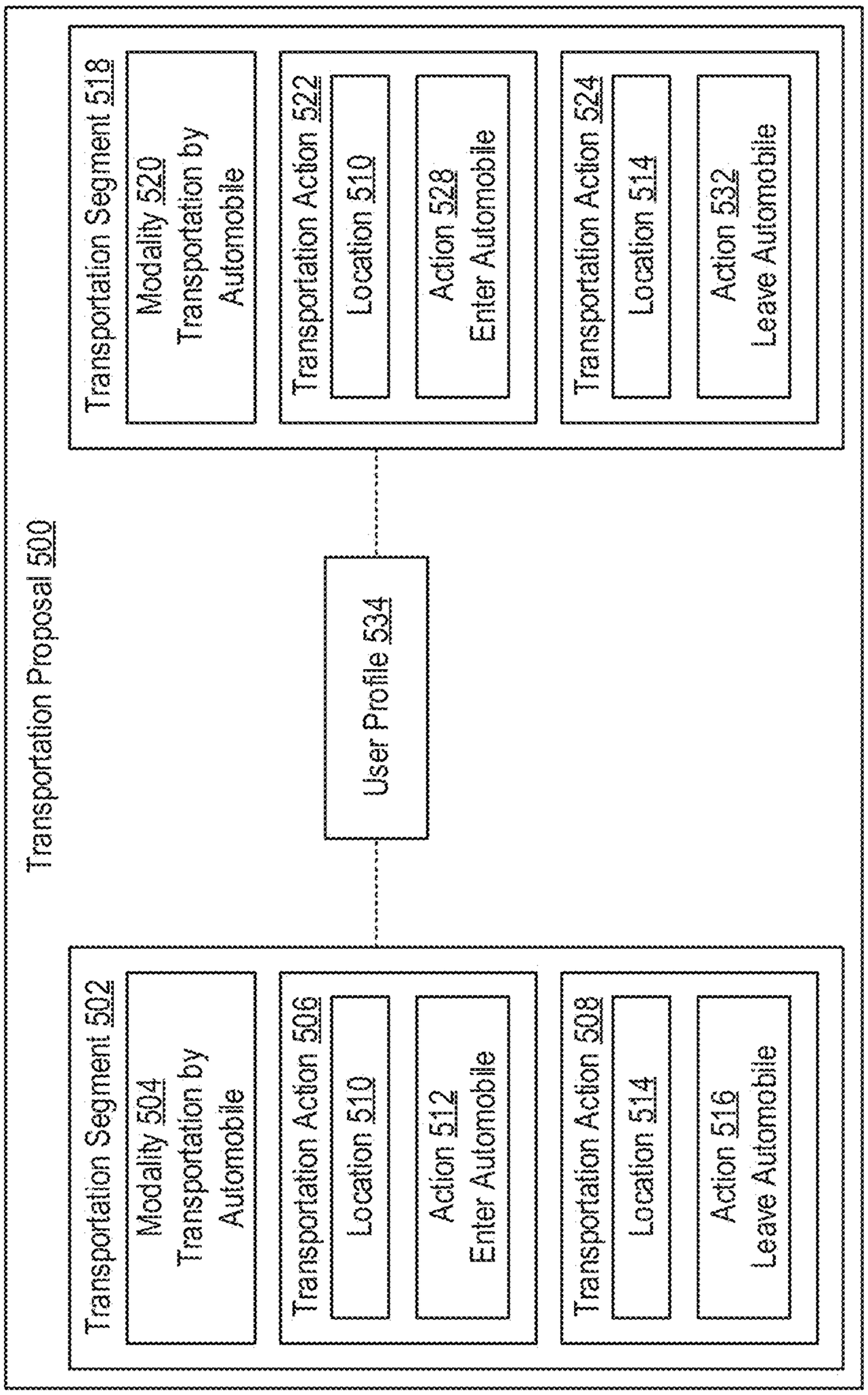
Transportation Proposal 500
Transportation Segment 502
Modality 504
Transportation by Automobile
Transportation Action 506
Location 510
Action 512
Enter Automobile
Transportation Action 508
Location 514
Action 516
Leave Automobile
User Profile 534
Transportation Segment 518
Modality 520
Transportation by Automobile
Transportation Action 522
Location 510
Action 528
Enter Automobile
Transportation Action 524
Location 514
Action 532
Leave Automobile

FIG. 5A

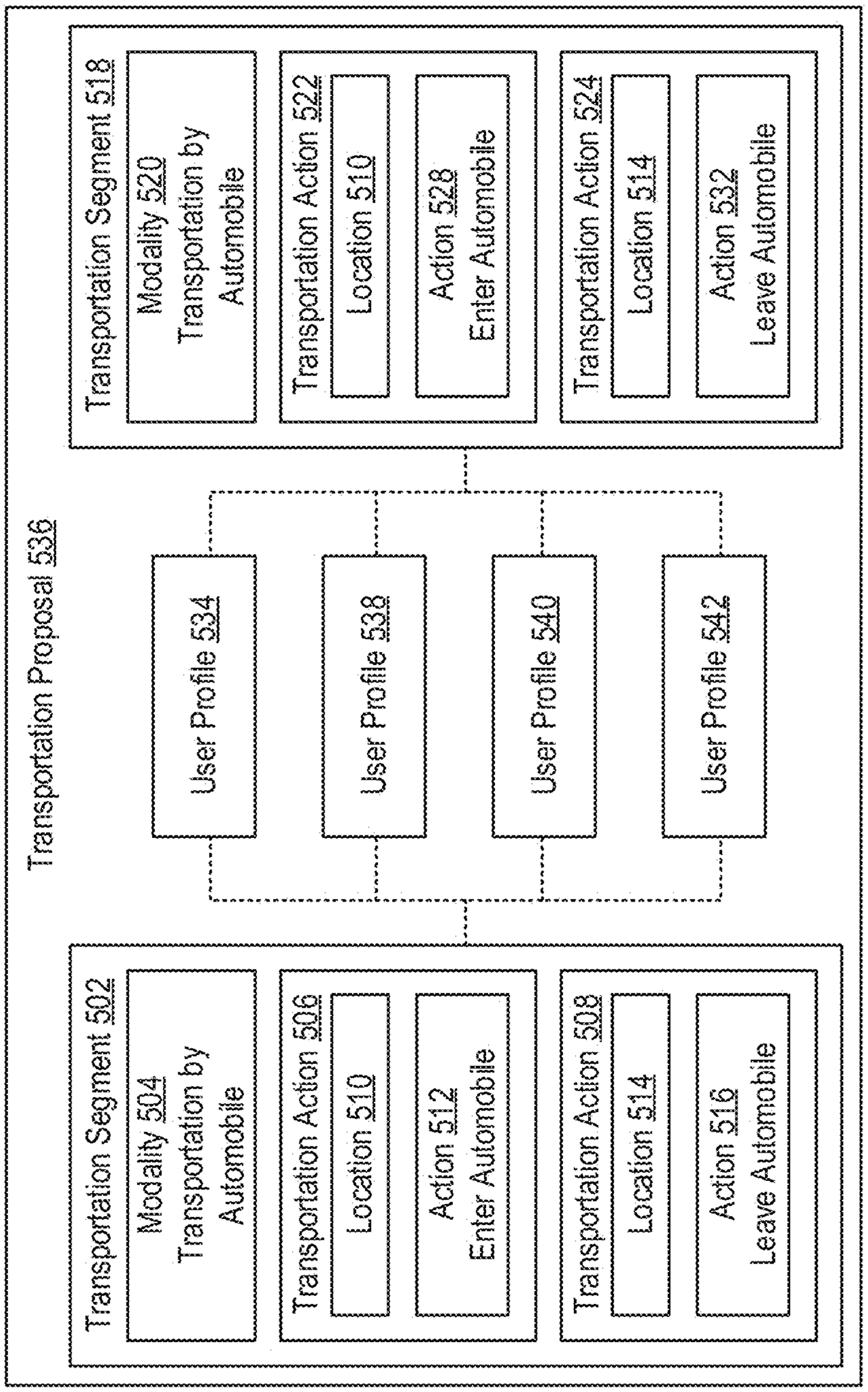
Transportation Segment 502
Modality 504
Transportation by Automobile
Transportation Action 506
Location 510
Action 512
Enter Automobile
Transportation Action 508
Location 514
Action 516
Leave Automobile
Transportation Proposal 536
User Profile 534
User Profile 538
User Profile 540
User Profile 542
Transportation Segment 518
Modality 520
Transportation by Automobile
Transportation Action 522
Location 510
Action 528
Enter Automobile
Transportation Action 524
Location 514
Action 532
Leave Automobile

FIG. 5B

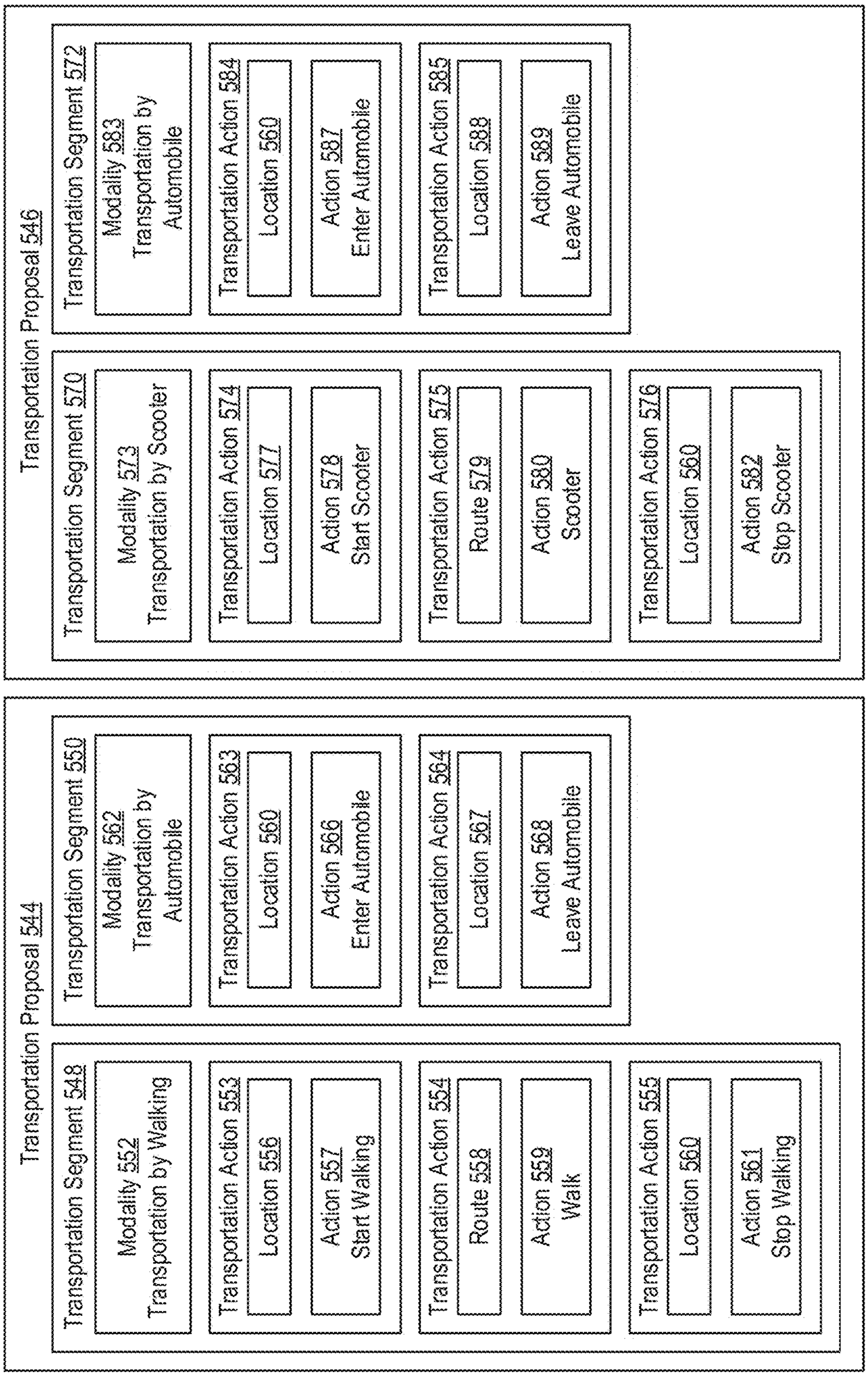
Transportation Proposal 544
Transportation Segment 550
Modality 562
Transportation by Automobile
Transportation Action 563
Location 560
Action 566
Enter Automobile
Transportation Action 564
Location 567
Action 568
Leave Automobile
Transportation Proposal 546
Transportation Segment 572
Modality 583
Transportation by Automobile
Transportation Action 584
Location 560
Action 587
Enter Automobile
Transportation Action 585
Location 588
Action 589
Leave Automobile
Transportation Proposal 548
Transportation Segment 548
Modality 552
Transportation by Walking
Transportation Action 553
Location 556
Action 557
Start Walking
Transportation Action 554
Route 558
Action 559
Walk
Transportation Action 555
Location 560
Action 561
Stop Walking
Transportation
Transportation Segment 570
Modality 573
Transportation by Scooter
Transportation Action 574
Location 577
Action 578
Start Scooter
Transportation Action 575
Route 579
Action 580
Scooter
Transportation Action 576
Location 560
Action 582
Stop Scooter

FIG. 5C

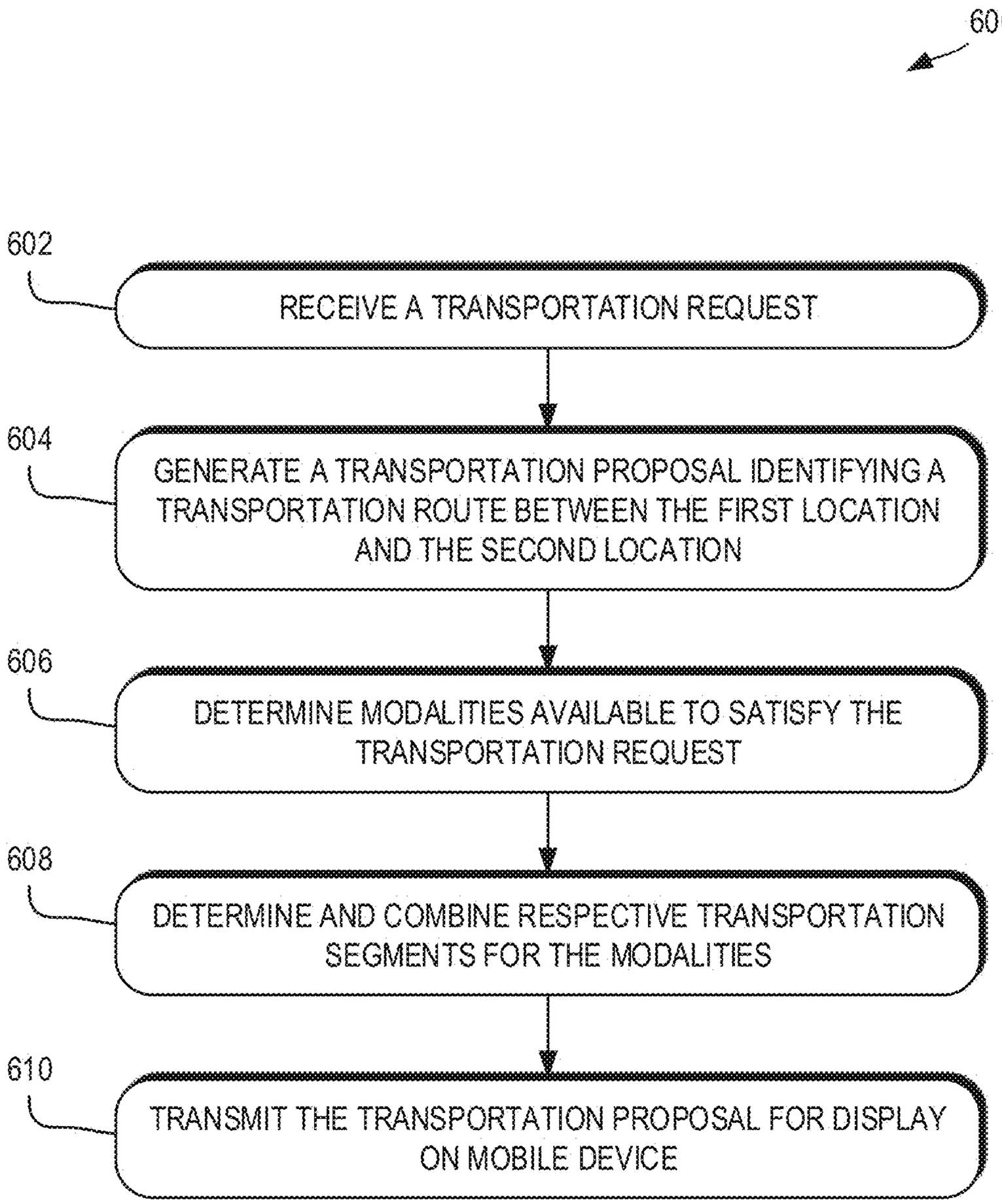
600
602
RECEIVE A TRANSPORTATION REQUEST
604
GENERATE A TRANSPORTATION PROPOSAL IDENTIFYING A TRANSPORTATION ROUTE BETWEEN THE FIRST LOCATION AND THE SECOND LOCATION
606
DETERMINE MODALITIES AVAILABLE TO SATISFY THE TRANSPORTATION REQUEST
608
DETERMINE AND COMBINE RESPECTIVE TRANSPORTATION SEGMENTS FOR THE MODALITIES
610
TRANSMIT THE TRANSPORTATION PROPOSAL FOR DISPLAY ON MOBILE DEVICE

FIG. 6

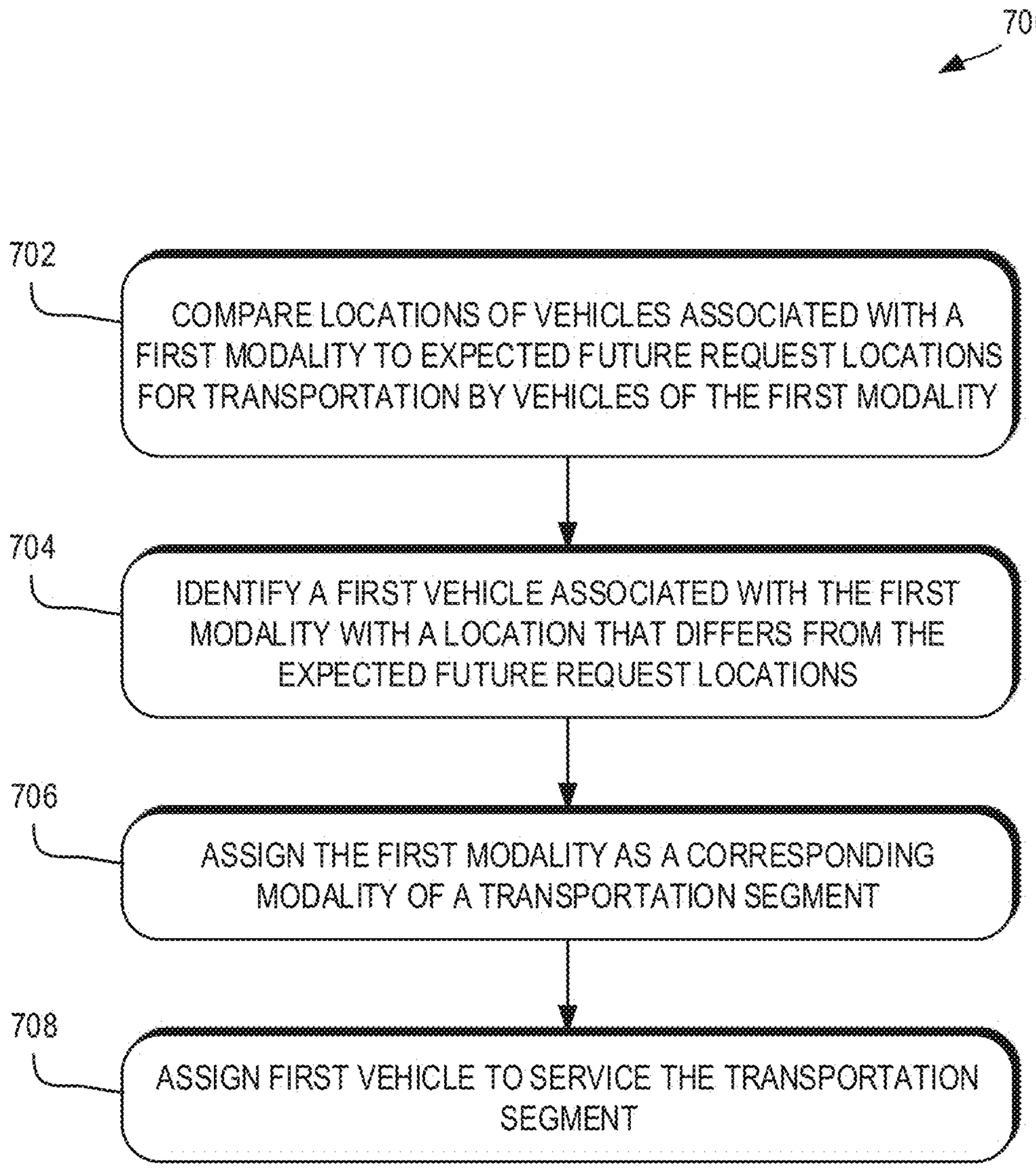
700
702
COMPARE LOCATIONS OF VEHICLES ASSOCIATED WITH A FIRST MODALITY TO EXPECTED FUTURE REQUEST LOCATIONS FOR TRANSPORTATION BY VEHICLES OF THE FIRST MODALITY
704
IDENTIFY A FIRST VEHICLE ASSOCIATED WITH THE FIRST MODALITY WITH A LOCATION THAT DIFFERS FROM THE EXPECTED FUTURE REQUEST LOCATIONS
706
ASSIGN THE FIRST MODALITY AS A CORRESPONDING MODALITY OF A TRANSPORTATION SEGMENT
708
ASSIGN FIRST VEHICLE TO SERVICE THE TRANSPORTATION SEGMENT

FIG. 7

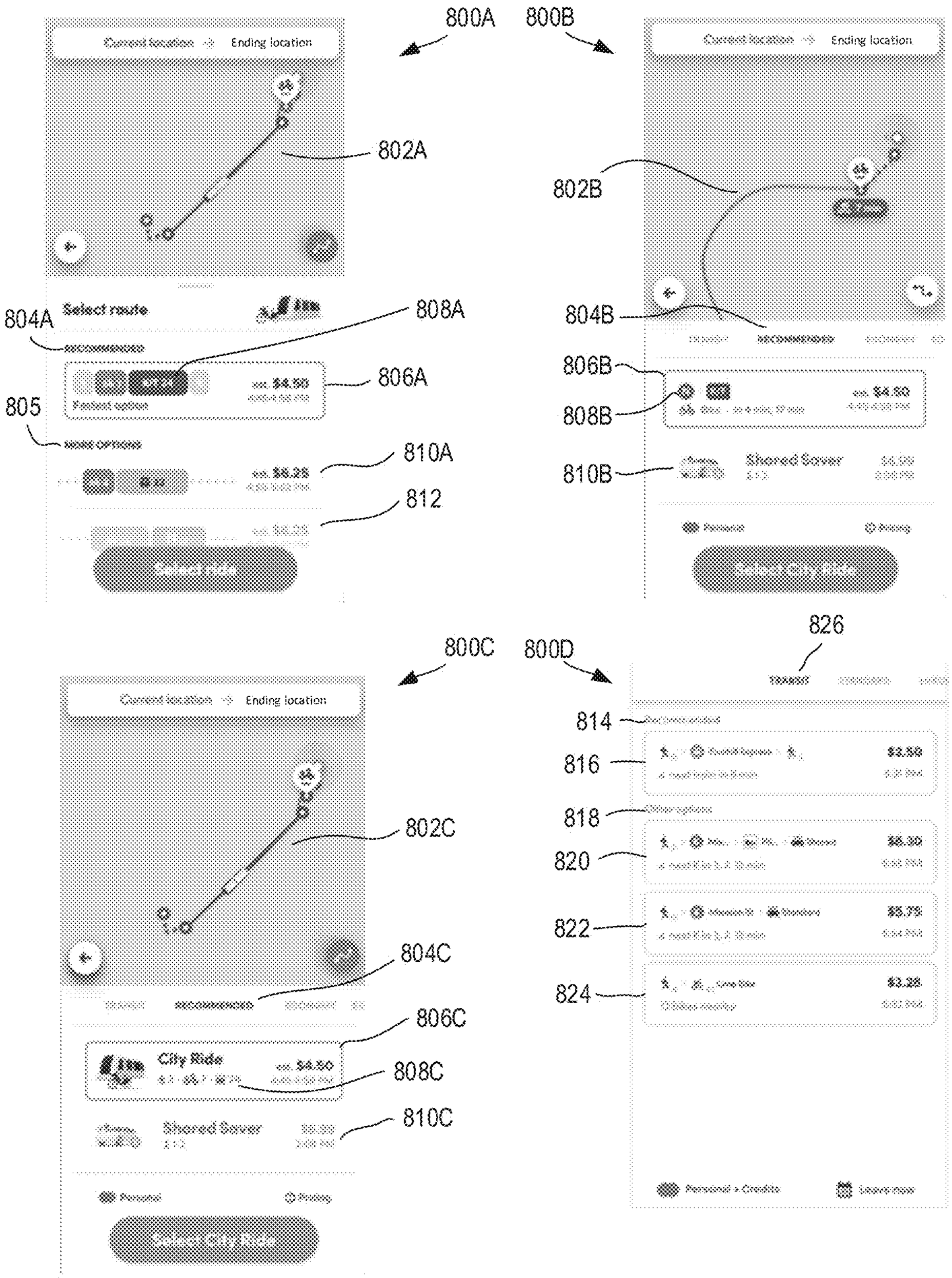
800A
800B
Current location
Ending location
802A
802B
804A
Select route
808A
804B
806B
806A
808B
805
810A
810B
812
826
800C
800D
814
816
818
820
822
824
802C
804C
806C
City Ride
808C
810C
Shared Saver

FIG. 8

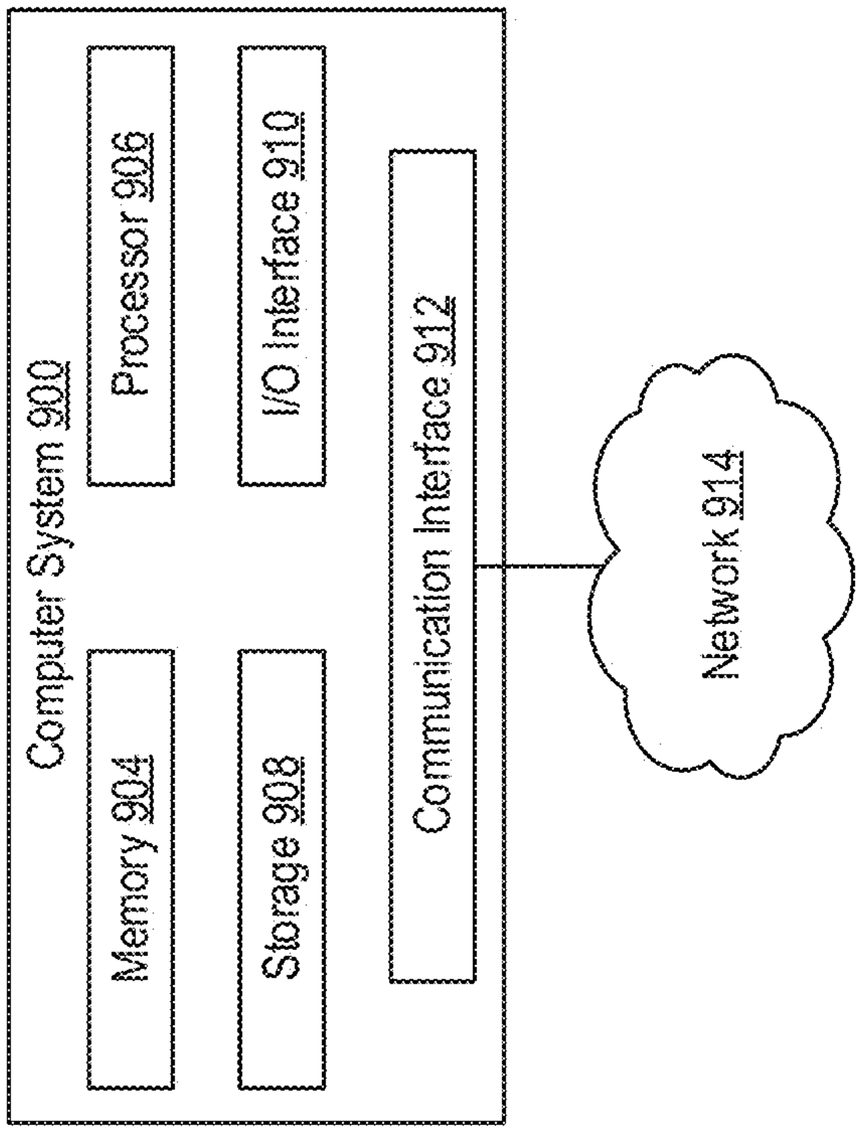
Computer System 900
Memory 904
Processor 906
Storage 908
I/O Interface 910
Communication Interface 912
Network 914

FIG. 9

TRANSPORTATION ROUTE PLANNING AND GENERATION

BACKGROUND

Individuals desiring transportation (e.g., transportation by vehicle) between two locations can submit transportation requests to transportation providers. In particular, users may identify specific locations between which transportation is desired. In response, transportation providers may identify multiple modes of transportation that may be used to transport the user between the identified locations.

SUMMARY

The present disclosure presents new and innovative systems and methods for generating and planning multi-modal transportation proposals. In a first aspect, a system is provided comprising a processor and a memory. The memory may store instructions which, when executed by the processor, cause the processor to receive, from a mobile device, a request for transportation to a destination location, identify an origin location of the mobile device, and determine modalities that are available to satisfy the request for transportation from the origin to the destination, wherein the modalities comprise a walking modality and a personal mobility modality. The memory may store further instructions which, when executed by the processor, cause the processor to determine respective segments for the modalities, combine at least a subset of the respective segments to form a route between the origin and the destination, wherein the at least a subset of the respective segments includes (i) a first segment corresponding to the personal mobility modality and (ii) a second segment corresponding to the walking modality, and transmit the route to the mobile device for display on the mobile device.

In a second aspect according to the first aspect, the first segment is longer than the second segment.

In a third aspect according to the second aspect, the second segment is less than or equal to 400 meters long and the first segment is greater than 400 meters long.

In a fourth aspect according to any of the first through third aspects, the personal mobility modality includes at least one of a bike modality and a scooter modality.

In a fifth aspect according to any of the first through fifth aspects, determining the respective segments comprises determine a battery level of a personal mobility vehicle associated with the personal mobility modality and determine the first segment based on the battery level of the personal mobility vehicle.

In a sixth aspect according to the fifth aspect, determining the first segment based on the battery level comprises determining a range of the personal mobility vehicle based on the battery level of the personal mobility vehicle and determining the first segment to have a distance less than or equal to the range of the personal mobility vehicle.

In a seventh aspect according to any of the first through third aspects, the at least a subset of the respective segments further includes a third segment corresponding to a third modality comprising at least one of an automobile modality, an autonomous automobile modality, a train modality, a bus modality, a boat modality, and a ferry modality.

In an eighth aspect according to the seventh aspect the first segment corresponds to a personal mobility vehicle and the third segment corresponds to a third vehicle associated with the third modality, and wherein the third vehicle is used to transport the personal mobility vehicle.

In a ninth aspect according to any of the seventh and eighth aspects, the third modality is selected according to a user preference associated with the transportation request.

In a tenth aspect according to the ninth aspect, the user preference specifies at least one of: (i) at least one preferred modality, (ii) a route preference for routes that include certain locations, (iii) a travel time preference for routes with short travel times, (iv) a cost preference for routes with low costs, (v) a health preference for routes associated with higher calorie expenditures, and (vi) an environmental preference for routes with lower resulting greenhouse gas emissions.

In an eleventh aspect according to any of the seventh through tenth aspects, the third modality is at least one of the automobile modality and the autonomous automobile modality, and the at least a subset of the respective segments includes a fourth segment corresponding to at least one of the train modality and the bus modality.

In a twelfth aspect according to any of the first through eleventh aspects, the mobile device displays at least an indication of the personal mobility modality and an indication of the walking modality.

In a thirteenth aspect, a method is provided comprising receiving, from a mobile device, a request for transportation to a destination location, identifying an origin location of the mobile device, and determining modalities that are available to satisfy the request for transportation from the origin to the destination, wherein the modalities comprise a walking modality and a personal mobility modality. The method may further include determining respective segments for the modalities, combining at least a subset of the respective segments to form a route between the origin and the destination, wherein the at least a subset of the respective segments includes (i) a first segment corresponding to the personal mobility modality and (ii) a second segment corresponding to the walking modality, and transmitting the route to the mobile device for display on the mobile device.

In a fourteenth aspect according to the thirteenth aspect, the first segment is longer than the second segment.

In a fifteenth aspect according to the fourteenth aspect, the second segment is less than or equal to 400 meters long and the first segment is greater than 400 meters long.

In a sixteenth aspect according to the fifteenth aspect, the personal mobility modality includes at least one of a bike modality and a scooter modality.

In a seventeenth aspect according to any of the thirteenth through sixteenth aspects, determining the respective segments comprises determining a battery level of a personal mobility vehicle associated with the personal mobility modality and determining the first segment based on the battery level of the personal mobility vehicle.

In an eighteenth aspect according to the seventeenth aspect, determining the first segment based on the battery level comprises determining a range of the personal mobility vehicle based on the battery level of the personal mobility vehicle and determining the first segment to have a distance less than or equal to the range of the personal mobility vehicle.

In a nineteenth aspect according to any of the thirteenth through eighteenth aspect, the at least a subset of the respective segments further includes a third segment corresponding to a third modality comprising at least one of an automobile modality, an autonomous automobile modality, a train modality, a bus modality, a boat modality, and a ferry modality.

In a twentieth aspect according to the nineteenth aspect, the first segment corresponds to a personal mobility vehicle

and the third segment corresponds to a third vehicle associated with the third modality, and wherein the third vehicle is used to transport the personal mobility vehicle.

In a twenty-first aspect according to any of the nineteenth and twentieth aspects, the third modality is selected according to a user preference associated with the transportation request.

In a twenty-second method according to the twenty-first aspect, the user preference specifies at least one of: (i) at least one preferred modality, (ii) a route preference for routes that include certain locations, (iii) a travel time preference for routes with short travel times, (iv) a cost preference for routes with low costs, (v) a health preference for routes associated with higher calorie expenditures, and (vi) an environmental preference for routes with lower resulting greenhouse gas emissions.

In a twenty-third aspect according to any of the nineteenth through twenty-second aspects, the third modality is at least one of the automobile modality and the autonomous automobile modality, and the at least a subset of the respective segments includes a fourth segment corresponding to at least one of the train modality and the bus modality.

In a twenty-fourth aspect according to any of the thirteenth through twenty-third aspects, the mobile device displays at least an indication of the personal mobility modality and an indication of the walking modality.

In a twenty-fifth aspect, a non-transitory, computer-readable medium is provided storing instructions which, when executed by a processor, cause the processor to receive, from a mobile device, a request for transportation to a destination location, identify an origin location of the mobile device, and determine modalities that are available to satisfy the request for transportation from the origin to the destination, wherein the modalities comprise a walking modality and a personal mobility modality. The non-transitory, computer-readable medium may store further instructions which, when executed by the processor, cause the processor to determine respective segments for the modalities, combine at least a subset of the respective segments to form a route between the origin and the destination, wherein the at least a subset of the respective segments includes (i) a first segment corresponding to the personal mobility modality and (ii) a second segment corresponding to the walking modality, and transmit the route to the mobile device for display on the mobile device.

The features and advantages described herein are not all-inclusive and, in particular, many additional features and advantages will be apparent to one of ordinary skill in the art in view of the figures and description. Moreover, it should be noted that the language used in the specification has been principally selected for readability and instructional purposes, and not to limit the scope of the disclosed subject matter.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1**A illustrates a transportation matching system according to exemplary embodiments of the present disclosure.

FIG. **1**B illustrates a transportation scenario according to an exemplary embodiment of the present disclosure.

FIG. **2** illustrates a system according to an exemplary embodiment of the present disclosure.

FIGS. **3**A-**3**B illustrate transportation proposals according to exemplary embodiments of the present disclosure.

FIGS. **4**A-**4**B illustrate transportation proposals according to exemplary embodiments of the present disclosure.

FIGS. **5**A-**5**C illustrate transportation proposals according to exemplary embodiments of the present disclosure.

FIG. **6** illustrates a method according to an exemplary embodiment of the present disclosure.

FIG. **7** illustrates a method according to an exemplary embodiment of the present disclosure.

FIG. **8** illustrates user interfaces according to exemplary embodiments of the present disclosure.

FIG. **9** illustrates a computer system according to an exemplary embodiment of the present disclosure.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

Aspects of the present disclosure involve systems and methods for generating transportation proposals identifying transportation routes between at least two locations. Each transportation proposal may include one or more transportation segments and each transportation segment may be associated with a specific modality indicating a specific mode of transportation a user should engage when traveling along the transportation segment. The generated transportation proposal may be presented for display on a user device, such as a mobile device. Techniques related to those discussed in the present disclosure are also discussed in (i) U.S. application Ser. No. 16/595,429, filed on Oct. 7, 2019, and titled "TRANSPORTATION PROPOSAL FILTRATION, COMPARISON, AND INCONVENIENCE MEASUREMENT," (ii) U.S. application Ser. No. 16/595,387, filed on Oct. 7, 2019, and titled "MULTI-MODAL TRANSPORTATION ROUTE DEVIATION DETECTION AND CORRECTION," and (iii) U.S. application Ser. No. 16/595,399, filed on Oct. 7, 2019, and titled "MULTI-MODAL TRANSPORTATION PROPOSAL GENERATION". The disclosures of these applications are hereby incorporated by reference.

Various processes and systems currently exist for determining transportation proposals that identify transportation routes between two locations, such as an origin location and a destination location. For example, many transportation providers use such processes and systems to provision vehicles for transporting users from a first, starting location, to a second, ending location. Transportation providers may include transportation networking companies (TNCs). TNCs may implement a transportation system that matches transportation requests with a dynamic transportation network of vehicles. In certain instances, the vehicles may include road-going vehicles and/or personal mobility vehicles. In some examples, some of the vehicles may be standard commercially available vehicles and some of the vehicles may be owned and/or operated by individuals. In some implementations, the vehicles may additionally or alternatively be autonomous (or partly autonomous). Accordingly, throughout the instant disclosure, references to a "vehicle operator" (or an "operator") may, where appropriate, refer to a human driving a vehicle, an autonomous vehicle control system, an autonomous vehicle, an owner of an autonomous vehicle, an operator of an autonomous vehicle, an attendant of an autonomous vehicle, a requesting user piloting a vehicle, and/or an autonomous system for piloting a vehicle. In one example, the TNC may implement multiple transportation systems, where each transportation system is responsible for coordinating transportation matching for a specific geographic region or set number of vehicles.

The transportation system may communicate with computing devices associated with the vehicles in the network, which may be separate computing devices and/or may be

computing devices that are integrated into the respective vehicles. In some examples, one or more of the computing devices may be mobile devices, such as a smart phone. Additionally or alternatively, one or more of the computing devices may be tablet computers, personal digital assistants, or any other type or form of mobile computing device. Additionally, one or more of the computing devices may include wearable computing devices (e.g., a driver-wearable computing device), such as smart glasses, smart watches, etc. In some examples, one or more of the computing devices may be devices suitable for temporarily mounting in a vehicle (e.g., for use by a requestor and/or an operator for a transportation matching application, a navigation application, and/or any other application suited for use by requestors and/or operators). Additionally or alternatively, one or more of the computing devices may be devices suitable for installing in a vehicle and/or may be a vehicle's computer that has a transportation management system application installed on the computer to provide transportation services to transportation requestors and/or communicate with the transportation system.

FIG. **1**A illustrates an example system **100** for matching transportation requests to a network of transportation vehicles according to one embodiment of the present disclosure. As illustrated, a transportation matching system **102** may communicate with user devices **104-106** requesting transportation. In some examples, the user devices **104-106** requesting transportation may include a requestor app **108** implemented by the transportation provider. The requestor app **108** may represent any application, program, and/or module that may provide one or more services related to requesting transportation services. For example, the requestor app **108** may include a transportation matching application for requestors. In some examples, the requestor app may match the user of the requestor app **108** (e.g., a transportation requestor) with transportation providers **110** through communication with the transportation matching system **102** via the communications network **112**. In addition, the requestor app **108** may provide the transportation matching system **102** with information about a requestor (including, e.g., the current location of the requestor) to enable the transportation matching system **102** to provide dynamic transportation matching services for the requestor and one or more transportation providers **110**, each of which may include a provider device **114**, **116**, **118**. Each provider device may include a provider app **120**, which may be any application program and/or set of instructions that may provide one or more services related to operating a vehicle and/or providing transportation matching services in conjunction with the transportation matching system **102** and the requestor app **108**.

In some examples, the requestor app **108** may coordinate communications and/or a payment between a requestor and a transportation provider **110**. According to some embodiments, the requestor app **108** may provide a map service, a navigation service, a traffic notification service, and/or a geolocation service. The provider app **120** may provide similar functions. In other implementations, the requestor app **108** may allow users to request access to certain vehicles, such as personal mobility vehicles (e.g., bikes and/or scooters).

The transportation matching system **102** may arrange transportation on an on-demand and/or ad-hoc basis by, e.g., matching one or more transportation requestors with one or more transportation providers **110**. For example, the transportation matching system **102** may provide one or more transportation matching services **122** for a networked transportation service, a ridesourcing service, a taxicab service, an automobile-booking service, an autonomous vehicle service, a personal mobility vehicle service, or some combination and/or derivative thereof. The transportation matching system **102** may include and/or interface with any of a variety of subsystems that may implement, support, and/or improve the transportation matching services **122**. For example, the transportation matching services **122** may include or otherwise interface with a matching system (e.g., that matches requestors to ride opportunities and/or that arranges for requestors and/or providers to meet), a mapping system, a routing system (e.g., to help a provider reach a requestor, to help a requestor reach a provider, and/or to help a provider reach a destination), a rating system (e.g., to rate and/or gauge the trustworthiness of a requestor and/or a provider), a payment system, and/or an autonomous or semi-autonomous driving system. The transportation matching system **102** may be implemented on various platforms, including a requestor-owned mobile device, a computing system installed in a vehicle, a server computer system, or any other hardware platform capable of providing transportation matching services to one or more requestors and/or providers.

Existing transportation matching systems are typically configured to identify and provide a particular modality of transportation between starting and ending locations. For example, FIG. **1**B depicts a transportation route **130** identifying a particular modality of transportation between a starting location (not labelled) and an ending location **136**. The transportation route **130** includes a single transportation segment **134** between the starting location and the ending location **136**. The transportation segment **134**, as generated, is to be serviced by one of the automobiles **132**A-C. For example, a user requesting transportation from the starting location to the ending location **136** may be picked up by one of the automobiles **132**A-C and driven along the route indicated by the transportation segment **134** to the ending location **136**.

In certain implementations, the transportation matching system may analyze and/or recommend transportation routes using modalities other than automobiles. For example, where the starting location and ending location **136** are closer together (e.g., shorter rides), the transportation matching system may generate transportation routes that utilize a personal mobility vehicle (e.g., a bike or a scooter). As another example, the transportation matching system may determine that a given starting location and/or ending location **136** are near transit stops for public transportation systems. In such a scenario, the transportation matching system may generate a transportation route from the starting location that utilizes a public transportation modality (e.g., a bus or a train).

Typical transportation matching systems, however, may not be able to generate transportation routes that combine multiple modalities into a single transportation proposal. Therefore, such transportation matching systems cannot capture cost or time savings associated with combining multiple modalities into a single transportation proposal. For example, in certain instances (e.g., during rush hour traffic), automobile-based modalities may be comparatively slower than other modalities, such as bikes or scooters. As another example, during rush hour or periods of high road congestion, it may be faster to take the train (i.e., use a public transit modality) between the two locations rather than to drive (i.e., use an automobile modality) between the two locations. In such a scenario, existing transportation matching systems may recommend public transportation modalities between

starting and ending locations for users located near transit stops. But such a recommendation may not be useful for all users. For instance, users that are not in close proximity to a transit stop may have to walk long distances over a significant amount of time to access the transit stop from their starting location. Alternatively, such users may have to walk long distances over a significant amount of time to leave a transit stop and arrive at their ending location. In either scenario, using public transportation may be slower than traveling by automobile. Such users may therefore be recommended transportation routes using automobiles, such as the automobiles **132**A-C.

Nevertheless, even users located far away from public transportation may receive faster transportation if they were able to use other modalities for transportation to the transit stops. For example, FIG. **1**B also depicts a transportation route **140** for transportation between starting location **142**, which corresponds to the starting location of the transportation route **130**, and ending location **136**. Rather than fulfilling the entire transportation route **140** with a single modality as in the transportation route **130**, the transportation route **140** includes two transportation segments **146**, **154** fulfilled by two different modalities (e.g., two different types of vehicles **144**, **152**). In particular, transportation segment **146** is fulfilled by bike **144** and transportation segment **154** is fulfilled by train **152**. While following the transportation route **140**, a user may walk from starting location **142** to location **148** at the beginning of the transportation segment **146** and pick up a bike **144** (e.g., a docked or dockless bike available for short term rental and/or use). The user can then ride the bike **144** from the location **148** to the location **150** at the end of the transportation segment **146** and drop off the bike **144** (e.g., at a bike dock or bike rack) before walking to location **156** at the start of segment **154**. The location **156** may correspond to a transit station (e.g., a train station), and the user may board the train **152** for transportation to the ending location **136** at the end of the segment **154**.

By generating transportation routes with multiple modalities, the transportation matching system may combine the benefits of each type of modality. For example, bikes, scooters, and/or walking may be optimal for traveling short or medium distances (e.g., first-mile and last-mile legs of multi-modal transportation proposals), while automobiles and trains may be better for longer distances. Similarly, automobiles may be more flexible in scheduling and routing, but may be more expensive, while trains and buses may be less flexible but also less expensive. By combining any one of these modalities into a single transportation proposal, transportation routes such as the transportation route **140** may capitalize on the relative benefits of each type of modality. For example, during rush hour or periods of high road congestion, the transportation route **140** may be able to allow more users to quickly and conveniently access faster and less expensive transportation via trains **152** (in comparison to automobiles). In another example, transportation by automobile may be faster and easier if disparate passengers meet at a common pick-up location, or if new passengers travel to pick-up locations closer to an existing route for an operator. In such instances, transportation proposals can be generated that identify transportation routes that guide users to use personal mobility vehicles for transportation to such pick-up locations.

Therefore, there exists a need to generate transportation routes that utilize different modalities. Additionally, these transportation routes have to be generated quickly (e.g., in real-time) to allow for subsequent processing after generation of the transportation routes (e.g., filtering and ranking) and before presentation of the transportation routes to a user. In particular, transportation routes that utilize different modalities may have to be generated and stored with enough information to enable users, interested in pursuing the transportation routes, to successfully follow the actions required to complete the route (e.g., use a specific modality along a specific route).

One solution to this problem is to automatically generate and store a transportation proposal for transportation between designated locations. The transportation proposal may include transportation segments, which may correspond to segments of a transportation route between the designated locations. The transportation segments may also correspond to different modalities for transportation. In certain instances, the transportation segments may also include transportation actions that specify actions required to follow the transportation proposal.

FIG. **2** depicts a system **200** according to an exemplary embodiment of the present disclosure. The system **200** may be configured to receive and process transportation requests and to generate transportation proposals for providing transportation according to the transportation requests. In particular, the system **200** may be configured to generate transportation proposals that utilize more than one modality to fulfill the transportation request. The system **200** includes a server **202**, a user device **250**, a user database **260**, and a vehicle database **266**.

The user device **250** may be configured to generate transportation requests **252** and to transmit the transportation requests to the server **202** (e.g., via a network connection). The user device **250** may include one or more computing devices, such as a smart phone, computer, tablet computer, and/or wearable computing device. The transportation requests **252** may specify a first location **254** and a second location **256**. For example, the transportation request **252** may request transportation from the first location **254** (e.g., an origin location) to the second location **256** (e.g., a destination location).

The server **202** may be configured to receive the transportation requests **252** from the user device **250** and to generate a transportation proposal **204** that may specify one or more routes, options, plans, itineraries, and/or selections for transportation that fulfills the transportation request **252**. In one example, the transportation proposal **204** may provision and/or provide details for transportation from the first location **254** to the second location **256**, as specified in the transportation request **252**.

In some instances, the transportation proposal **204** may include one or more transportation segments **206**, **224**, **236**, which may correspond to different steps or subsets of transportation between the first location **254** and the second location **256**. Each transportation segment **206**, **224**, **236** may have a corresponding modality **208**, **226**, **238** and/or vehicle **210**, **228**, **240**. The modalities **208**, **226**, **238** may specify a type of transportation. For example, the modalities **208**, **226**, **238** may include one or more of transportation by automobile, transportation by bus, transportation by train, transportation by personal mobility vehicle, and transportation by walking. Transportation by a personal mobility vehicle may include transportation by vehicles capable of transporting individual users. Transportation by a personal mobility vehicle may include transportation by rideable vehicles, such as transportation by scooter and transportation by bike, may include transportation by a docked vehicle (e.g., a vehicle that has to be accessed from and returned to docks in fixed locations) and/or transportation by an

undocked or dockless vehicle (e.g., a vehicle that does not have to be returned to docks).

Each of the transportation segments **206**, **224**, **236** includes a vehicle **210**, **228**, **240**. The vehicles **210**, **228**, **240** may be associated with the modality **208**, **226**, **238** (e.g., may be vehicles **210**, **228**, **240** of the type specified by the modality **208**, **226**, **238**) and may be selected to provide transportation to fulfill at least a portion of the transportation proposal **204** associated with the transportation segments **206**, **224**, **236**. For example, the vehicles **210**, **228**, **240** may include one or more of an automobile (e.g., an autonomous automobile, a semi-autonomous automobile, and/or an automobile operated by a vehicle operator), a train, a bus, a boat, a ferry, a bike (e.g., a docked or dockless bike), and a scooter. In certain implementations, the vehicle **210**, **228**, **240** may identify a specific vehicle for use in fulfilling the transportation segments **206**, **224**, **236**. In other implementations, the vehicles **210**, **228**, **240** may specify a location from which a vehicle may be accessed to fulfill the transportation segment (e.g., a dock from which a bike can be accessed, or a transit stop from which a train or bus can be accessed). In certain implementations, one or more transportation segments **206**, **224**, **236** may not include a vehicle **210**, **228**, **240**. For example, where the modality **208**, **226**, **238** of a transportation segment **206**, **224**, **236** is transportation by walking, the transportation segment **206**, **224**, **236** may not specify a vehicle **210**, **228**, **240** because no vehicle **210**, **228**, **240** is necessary. As another example, if a transportation segment **206**, **224**, **236** occurs far enough in the future (e.g., more than 10, 20, or 30 minutes in the future), specific vehicles **210**, **228**, **240** may not be assigned to service the transportation segment **206**, **224**, **236** because the locations of any assigned vehicles **210**, **228**, **240** may change before the transportation segment **206**, **224**, **236** begins.

The server **202** may identify the vehicles **210**, **228**, **240** based on the vehicle database **266**. In particular, the vehicle database **266** may track and store current (e.g. real time) vehicle locations **268** in association with a modality **270**. The vehicle locations **268** may specify current locations for one or more vehicles associated with the modality **270**. The vehicle database **266** may also store a vehicle availability **272** in association with the modality **270**. The vehicle availability **272** may specify a current availability of vehicles associated with the modality **270**. For example, for personal mobility vehicles, the vehicle availability **272** may specify whether the personal mobility vehicles are currently in use. Similarly, for transportation by automobile, the vehicle availability **272** may specify whether the automobile currently has a customer. As another example, for transportation by automobile, the vehicle availability **272** may specify how many passengers the automobile currently has (e.g., whether the automobile has room for additional passengers).

The server **202** may use the vehicle availability **272** and/or modality **270** to select the vehicles **210**, **228**, **240** for the transportation segments **206**, **224**, **236**. For example, the server **202** may identify vehicles based on the vehicle locations **268** that are located near or between the first location **254** and the second location **256**. The server **202** may also determine, based on the vehicle availability **272**, which of the vehicles are available to provide transportation in association with the transportation request **252**. For example, the server **202** may identify vehicles that are not in use, do not have passengers, and/or will be available to service a request before an anticipated time of a transportation segment **206**, **224**, **236** as potential vehicles for the transportation segment **206**, **224**, **236**. The server **202** may then select between the potential vehicles to assign the vehicles **210**, **228**, **240** to the transportation segments **206**, **224**, **236**.

For certain modalities **270**, rather than storing locations of the vehicles themselves, the vehicle database **266** may store other types of locations associated with the modality **270**. In certain implementations, the vehicle locations **268** may include locations from which vehicles may be accessed. For example, for transportation by bus and/or transportation by train, the vehicle locations **268** may indicate transit stops where a user can board or disembark buses or trains associated with the vehicle locations **268**. As another example, for transportation by docked personal mobility vehicle, the vehicle locations **268** may indicate the predefined, fixed locations of docks from which the personal mobility vehicles can be accessed. In such implementations, the vehicle availability **272** may indicate the availability of vehicles at the locations associated with the modality. For example, for transportation by docked bike, the vehicle availability **272** may indicate an availability level (e.g., a number of available bikes or percentage of total bikes available) for the docks located at the vehicle locations **268**. As another example, for transportation by dockless bike, the vehicle availability **272** may indicate whether specific bikes are available for user. In still further implementations, the vehicle availability **272** may indicate times at which vehicles are available at the vehicle locations **268**. For example, for transportation by bus or transportation by train, the vehicle availability **272** may indicate the times at which buses or trains arrive at and/or depart from the transit locations identified by the vehicle locations **268**.

In still further implementations, the vehicle database **266** may store predicted information regarding vehicles associated with modalities **270**. For example, the vehicle locations **268** may store predicted future locations of vehicles associated with the modality **270** and the vehicle availability **272** may include predicted future availability of vehicles associated with the modality **270**. The server may use this information to identify vehicles **210**, **228**, **240** or modalities **208**, **226**, **238** for transportation segments **206**, **224**, **236** that correspond to future actions. For example, the transportation segments **224**, **236** may occur after the transportation segment **206**. Accordingly, locations of vehicles associated with the modalities **226**, **238** may change during performance of the transportation segment **206**. The server **202** may accordingly utilize predicted locations and/or predicted availability to identify vehicles that are expected to be available at the start of transportation segment **224**. In certain implementations, rather than identifying specific vehicles **228**, **240** when generating the transportation proposal **204**, the server **202** may include modalities **226**, **238** identifying a type of transportation for certain transportation segments **224**, **236** and may select associated vehicles **228**, **240** later (e.g., closer to when transportation identified by the transportation segments **224**, **236** begins).

Although depicted as storing vehicle locations **268** and vehicle availability **272** in association with a single modality **270**, the vehicle database **266** may store such information regarding multiple modalities. For example, the vehicle database **266** may store information regarding each of the modalities discussed above.

The transportation segments **206**, **224**, **236** may include transportation actions **212**, **218**, **230**, **232**, **234**, **242**, **244**, **246**, each of which specify one or more actions to be performed by a user or other vehicle operator necessary to provide transportation according to the transportation segment **206**, **224**, **236**. For example, the transportation actions

212, 218 include actions 216, 222. The actions 216, 222 may specify, e.g., actions required to initiate or perform the transportation associated with the transportation segment 206. For example, the transportation action 212 may specify that a user access a bike from a location 214 and the transportation action 218 may specify that the user ride the bike along a particular route 220. The transportation actions 230, 232, 234, 242, 244, 246 may include similar actions and/or information.

In certain embodiments, the transportation proposal 204 may specify transportation according to two or more modalities (i.e., two or more different types of transportation). For example, the modalities 208, 226, 238 of the transportation segments 206, 224, 236 may differ from one another. The server 202 may be configured to select the modalities 208, 226, 238 based on information stored in the vehicle database 266 and/or the user database 260. For example, the server 202 may compare the first location 254 and the second locations 256 to the vehicle location 268 and the vehicle availability 272 to determine whether vehicles are available to service all or part of a transportation route between the first location 254 and the second location 256. The server 202 may also use information stored in the user database 260 to identify modalities for servicing the transportation request 252. The user database 260 may store information regarding user profiles 262. The user profiles 262 may include information regarding users who submit transportation requests 252. For example, the user database 260 may store user preferences 264 in association with user profiles 262. The user preferences 264 may specify preferred or disliked transportation modalities for a user associated with the user profile 262. For example, the user preferences 264 may specify one or more preferred modalities and/or one or more disliked modalities of a user associated with the user profile. The user preferences 264 may also specify that a user has a route preference for routes that include certain locations (e.g., faster, slower, more scenic roads) or routes that avoid certain locations (e.g., dangerous, frequently-congested roads). The user preferences 264 may also specify that a user has preferences for certain types of routes, such as a cost preference for routes that are less expensive, a health preference for healthier routes (e.g., routes with a higher calorie expenditures), and/or an environmental preference for routes that are more environmentally friendly (e.g., have lower resulting greenhouse gas emissions). The user preferences 264 may be user specified (e.g., entered and/or configured by a user associated with the user profile 262) and/or may be derived from user behaviors (e.g., previous acceptance and/or rejection of previous transportation proposals). The server 202 may analyze user preferences 264 stored in association with a user profile 262 that submitted the transportation request 252. The server 202 may then select one or more of the modalities 208, 226, 238 based on the user preferences 264 (e.g., to include preferred modalities and/or to exclude disliked modalities).

In certain implementations, the server 202 may generate more than one transportation proposal 204. For example, the server 202 may generate multiple transportation proposals 204 in response to the received transportation request 252. The server 202 may then select from among the generated transportation proposals 204 one or more transportation proposals 204 for presentation to the user device 250.

One or more of the server 202, the user device 250, the user database 260, and the vehicle database 266 may be implemented by a computer system. For example, one or more of the server 202, the user device 250, the user database 260, and the vehicle database 266 may include a processor and/or memory configured to implement one or more operational features. In particular, the memory may store instructions which, when executed by the processor, cause the processor to implement the one or more operational features of the server 202, the user device 250, the user database 260, and/or the vehicle database 266.

FIGS. 3A-3B illustrate transportation proposals 300, 396 according to exemplary embodiments of the present disclosure. The transportation proposals 300, 396 may depict exemplary implementations of the transportation proposals 204 generated by the server 202 in response to a transportation request 252. Referring initially to FIG. 3A, the transportation proposal 300 includes four transportation segments 302, 304, 306, 308. Each of the transportation segments 302, 304, 306, 308 includes a single modality 310, 330, 350, 368. In particular, the transportation segment 302 corresponds to the modality 310 of transportation by walking, the transportation segment 304 corresponds to the modality 330 of transportation by scooter, the transportation segment 306 corresponds to the modality 350 of transportation by train, and the transportation segment 308 corresponds to the modality 368 of transportation by automobile. In combination, a user following the transportation segments 302, 304, 306, 308 may be transported between two desired locations (e.g., the first location 254 and the second location 256 of the transportation request 252).

The transportation segments 302, 304, 306, 308 each include multiple transportation actions 312, 314, 316, 332, 334, 336, 352, 354, 370, 372. The transportation actions 312, 314, 316, 332, 334, 336, 352, 354, 370, 372 may specify actions a user may take in order to receive or otherwise engage in transportation according to the transportation segments 302, 304, 306, 308 and the transportation proposal 300. For example, the transportation actions 312, 314, 316, 332, 334, 336, 352, 354, 370, 372 may specify how a user can access vehicles associated with certain modalities (e.g., accessing or unlocking bikes or scooters, being picked up in an automobile, boarding a train or bus). In some instances, the transportation actions 312, 314, 316, 332, 334, 336, 352, 354, 370, 372 may be associated with certain locations. These locations may specify where a user should perform or follow actions associated with the transportation actions 312, 314, 316, 332, 334, 336, 352, 354, 370, 372. For example, the transportation action 312 specifies with action 320 that the user should start walking at a location 318 (e.g., according to the modality 310 of transportation by walking). The location 318 may correspond to a starting location of the user (e.g., the first location 254 of a received transportation request 252). Transportation action 314 specifies with action 324 that a user should walk along the route 322. Also, transportation action 316 specifies with action 328 that the user should stop walking at location 326. Accordingly, by following the transportation actions 312, 314, 316, the user will walk from the location 318 to the location 326.

The transportation actions 332, 334, 336 of the transportation segment 304 similarly specify the actions a user should take to utilize a scooter for transportation. At transportation action 332, the user will start riding a scooter according to action 340 at location 326. The location 326 is the same for both transportation actions 316 and 332. The common location 326 may indicate that the user stops walking at the location of a scooter available for use and starts riding the scooter according to action 340. Transportation action 334 indicates that the user should ride the scooter along the route 342. At transportation action 336, the user may stop riding the scooter at the location 346 according to action 348.

According to transportation action **352** of the transportation segment **306**, the user may then board a train according to action **360** at the location **346**. As transportation actions **336** and **352** both include the same location **346**, the user may stop riding the scooter at a transit station located at location **346** and board a train located at the location **346** (i.e., the same location). Transportation action **352** also includes a time **358**, which may designate a time by which a user has to board the train according to action **360**. For example, the time **358** may indicate when the train a user is supposed to board will depart from the transit station, or a time at which the train will arrive at the transit station. Transportation action **354** corresponds to the user disembarking the train at location **362** according to action **366** at a time **364**.

At transportation action **370** of the transportation segment **308**, the user may then enter an automobile according to action **376** at the location **362**. For example, the user may enter an automobile operated by another person or operated by an autonomous or semi-autonomous vehicle system at a pickup location near the transit stop at location **362** where the user disembarked the train according to action **366**. The automobile may been drive the user from location **362** to location **378** of the transportation action **372**, at which point the user may leave the automobile according to action **381**.

By following the transportation actions **312**, **314**, **316**, **332**, **334**, **336**, **352**, **354**, **370**, **372** of the transportation segments **302**, **304**, **306**, **308**, the user may follow a multi-modal transportation route corresponding to the transportation proposal **300**. In particular, the user may walk to a scooter, scooter to a transit stop associated with a train, ride the train to a second transit stop associated with the train, and ride in an automobile to their final destination.

Other multi-modal routes may be generated for transportation between the same locations **318**, **378**. For example and with reference to FIG. **3**B, the transportation proposal **396** provides an alternative multi-modal transportation route between the locations **318**, **378**. The transportation proposal **396** includes transportation segments **302**, **306**, identical to the transportation proposal **300**. However, the transportation segment **380** corresponding to the modality **330** of transportation by scooter differs from the transportation segment **304** of the transportation proposal **300**. Transportation segment **380** includes the transportation actions **332**, **334** by which a user starts riding a scooter at location **326** and follows a route **342**. The route **342** may lead the user to the location **346** of transportation action **352** (e.g., a transit stop associated with a train), at which the user may board the train according to action **360**. However, the transportation segment **380** does not indicate that the user stops using the scooter at the location **346**. Rather, after disembarking the train according to action **366** at location **362** of the transportation action **354**, the user resumes scootering at location **362** according to action **384** of transportation action **382**. The user then rides the scooter according to action **390** along route **388** of the transportation action **386** and stops riding the scooter at location **378** according to action **394** of the transportation action **392**. Therefore, by following the transportation actions **312**, **314**, **316**, **332**, **334**, **352**, **354**, **382**, **386**, **392**, the user may walk to a scooter, which the user rides to the transit station at location **346** and brings the scooter with them onto the train when boarding according to action **360**. Then, after disembarking the train (i.e., with the scooter) according to action **366** at location **362**, the user may ride the scooter to their final destination at location **378**. In the transportation proposal **396**, the transportation segments **306**, **380** may be considered parallel transportation segments because of the transportation segment **306** occurs while the transportation segment **380** is still in progress (e.g., after the transportation segment **380** begins and before completing the transportation segment **380**), as the user will not complete their scooter ride until reaching their final destination at location **378**.

Transportation proposals such as the transportation proposal **396** that include parallel transportation segments **306**, **380** may assist with reallocating vehicles as needed according to marketplace conditions. For example, personal mobility vehicles such as bikes or scooters may typically be needed in different locations at different times (e.g., according to typical user traffic, ridership patterns, and/or the like). Typically, such personal mobility vehicles may be manually relocated (e.g., by service workers associated with or working on behalf of a TNC). Such relocation services may incur additional costs, for example, to pay the service workers who manually relocate the personal mobility vehicles. However, transportation proposals that instruct users to travel with personal mobility vehicles (e.g., bikes, scooter) using other modalities (e.g., trains, buses, automobiles) may allow for targeted reallocation of personal mobility vehicles with minimal additional cost. For example, if the server **202** determines that a user associated with a received transportation request **252** is traveling to a location at which personal mobility vehicles are likely to be in high demand in the future, the server **202** may generate a transportation proposal such as the transportation proposal **396** that instructs the user to travel with the personal mobility vehicle using another modality (i.e., using a train, a bus, and/or an automobile). In certain implementations, transportation proposals **396** that include such parallel transportation segments **306**, **380** may be discounted at least in part to account for the defrayed cost of relocating the personal mobility vehicle. Parallel transportation segments may also be generated to transport vehicles other than personal mobility vehicles. For example, a transportation proposal may be generated to transport an automobile using a boat or ferry.

FIGS. **4**A-**4**B illustrate transportation proposals **400**, **486** according to exemplary embodiments of the present disclosure. The transportation proposals **400**, **486** may depict exemplary implementations of the transportation proposals **204** generated by the server **202** in response to a transportation request **252**. In particular, the transportation proposals **400**, **486** may be example transportation proposals that include segments with modalities of the same type.

Referring initially to FIG. **4**A, transportation proposal **400** includes four transportation segments **402**, **404**, **406**, **408**. Transportation segment **402** corresponds to the modality **410** of transportation by walking. In particular, transportation action **412** indicates that a user will start walking according to action **420** from a location **418**. Transportation action **414** specifies that a user will walk along a route **422** according to action **424** until, according to transportation action **416**, the user will stop walking at the location **426** according to action **428**. For the transportation action **432** of the transportation segment **404**, a user may then board a train at the location **426** at time **438**. The user may ride the train until disembarking the train according to action **446** of the transportation action **434** at location **442** and at time **444**. The user may then board a second train at location **442** and time **456** according to action **458** of the transportation action **450** of the transportation segment **406**. For example, according to transportation segments **404**, **406** the user may transfer trains in order to travel closer to the final destination. The user may then ride the second train to location **460** according to transportation action **452**, at which point the user may

disembark the train as specified in action **464** at the time **462**. The user may then walk to their final destination as indicated in the transportation segment **408**. In particular, according to transportation action **468**, the user may start walking at location **460** as specified in action **476** after disembarking the second train. The user may then walk along the route **478** according to action **480** of the transportation action **470**. The user may then arrive at their final destination at location **482** and may stop walking according to action **484** of the transportation action **472**.

By following the transportation proposal **400**, the user may walk to a first transit stop according to transportation segment **402** and board a first train at the first transit stop and ride the train to a second transit stop according to transportation segment **404**. The user may then board a second train at the second transit stop and ride the second train to another location according to the transportation segment **406** and may walk to their final destination at location **482** according to the transportation segment **408**. By combining transportation segments **404**, **406** with same modality **430**, **448** of transportation by train, the transportation proposal **400** may be better able to utilize existing public transportation or other transportation resources. For example, a user may initially be located closer to a transit station for the first train line, but the first train line may not run close to the user's final destination. However, the second train line may run closer to the user's final destination but may be located further from the user's starting location. By identifying a common location **442** for the first and second train lines, the transportation proposal **400** may allow the user to take two different trains instead of having to rely on different modalities, which may be more expensive and/or slower. The transportation proposal **400** also includes two transportation segments **402**, **408** with the same modality **410**, **466** of transportation by walking. Such common transportation segments **402**, **408** may enable more simple transportation for the user (e.g., it may be easier to walk than to locate and access a personal mobility vehicle) and/or may reduce the overall cost of fulfilling the transportation proposal **400**.

Transportation proposals with transportation segments having common modalities may also be generated according to user preferences. For example and with reference to FIG. **4**B, the transportation proposal **486** includes transportation segments **488**, **490** having modalities **487**, **495** of transportation by automobile. Specifically, a user may enter the automobile at their starting location **418** according to action **492** of transportation action **491**. The user may then ride the automobile to location **426**, at which point the user may leave the automobile according to action **494** of the transportation action **493**. The transportation segment **404** is the same for both transportation proposals **400**, **486**. Accordingly, the user may board the train at location **436** and ride the train to location **442** as discussed above. However, rather than boarding the second train as indicated in transportation segment **406**, transportation segment **490** specifies that the user may ride in an automobile to their final destination. Specifically, the user may enter the automobile at location **442** according to action **497** of the transportation action **496**. The user may then ride in the automobile to location **442**, at which point the user may leave the automobile according to action **499** of transportation action **498**.

The transportation proposal **486** may be generated to account for a user's preferences (e.g., user preferences **264** corresponding to a user profile **262** that is associated with a received transportation request **252**). For example, the user preferences **264** may indicate that a user associated with the transportation proposal **486** dislikes transportation by walking. Accordingly, the transportation segments **488**, **490** may be generated with modalities other than transportation by walking (e.g., transportation by automobile). The user preferences **264** may also indicate that the user does not like transfers between public transit modalities. Accordingly, the transportation segment **490** may be generated to provide transportation from the location **442** at which the user disembarks the train. In alternative implementations (e.g, implementations other than those depicted in FIG. **4**B), a transportation segment may be generated such that the user takes a single train and does not disembark the train at location **442** (e.g., takes the train to a different transit stop). Additionally or alternatively, the user preferences **264** may specify that the user prefers transportation proposals **486** that are comparatively faster (e.g., time and/or distance) than other transportation proposals. Accordingly, the modalities **487**, **495** may be assigned as transportation by automobile, which may be faster than other modalities such as transportation by walking, transportation by bus, transportation by train, and/or transportation by personal mobility vehicle.

FIGS. **5**A-**5**C illustrate transportation proposals **500**, **536**, **544**, **546** according to exemplary embodiments of the present disclosure. The transportation proposals **500**, **536**, **544**, **546** may be generated to account for one or more associated users. The associated users may be identified by user profiles, such as user profiles **262** stored in the user database **260**. Referring initially to FIG. **5**A, transportation proposal **500** includes two transportation segments **502**, **518** having the same modality **504**, **520** transportation by automobile. The transportation segments **502**, **518** also have similar transportation actions **506**, **508**, **522**, **524**. Both of the transportation actions **506**, **522** include actions **512**, **528** specifying that the user enter an automobile at location **510**. Also, the transportation actions **508**, **524** both have actions **516**, **532** specifying that the user leave the automobile at location **514**. Both transportation segments **502**, **518** are associated with a single user profile **534** and may be executed at least partially in parallel (e.g., at least partially at the same time). For example, a user associated with the user profile **534** may request two automobiles for transportation between the same location (e.g., for a number of riders larger than a single automobile can transport). The user associated with the user profile **534** may then be able to centrally process, pay for, and monitor the performance of both transportation segments **502**, **518**.

Referring to FIG. **5**B, the transportation proposal **536** includes identical transportation segments **502**, **518** to the transportation proposal **500**, but with four corresponding user profiles **534**, **538**, **540**, **542**. Multiple user profiles **534**, **538**, **540**, **542** associated with the transportation segments **502**, **518** may allow multiple users to process, pay for (e.g., split payment of), and monitor the performance of the transportation segments **502**, **518**. In certain implementations, different user profiles may be associated with each transportation segments **502**, **518**. For example, user profiles associated with users riding in the automobiles associated with either the transportation segment **502** or the transportation segment **518** may be assigned to the corresponding transportation segment. In such instances, a user profile associated with the user who requested transportation may also be associated with both transportation segments **502**, **518** so the user can process, pay for, and/or monitor performance of both transportation segments **502**, **518**.

Referring to FIG. **5**C, a transportation proposals for a first user may also be generated to include one or more transportation segments that overlap with one or more transportation segments of a different transportation proposal for a

different user. For example, the transportation proposals **544**, **546** respectively include transportation segments **550**, **572** that partially overlap. Specifically, both transportation segments **550**, **572** include transportation actions **563**, **584** with actions **566**, **587** specifying that users associated with the transportation proposals **544**, **546** should enter an automobile at location **560**. However, the transportation segments **550**, **572** include different transportation actions **564**, **585** at the end of the associated users' automobile rides. Specifically, the transportation action **564** includes an action **568** specifying that the user should leave the automobile at location **567**, while the transportation action **585** includes an action **589** specifying that the user should leave the automobile at location **588**. The different ending locations **567**, **588** of the transportation segments **550**, **572** may result from different destinations for users associated with the transportation proposals **544**, **546**. For example, the location **567** may correspond to a final destination of a first user associated with the transportation proposal **544**, while the location **588** may correspond to a final destination of a second user associated with the transportation proposal **546**. In this way, the users associated with the transportation proposals **544**, **546** may be able to both utilize a single vehicle, e.g., if users destinations are near one another and/or are in similar directions relative to the users' starting locations. Such overlapping transportation segments **550**, **572** may help increase system capacity for a TNC providing the transportation proposals **544**, **546** by increasing the number of passengers serviced by each vehicle. Overlapping transportation segments **550**, **572** may also reduce the cost to the users associated with the transportation proposals **544**, **546** (e.g., because the users can at least partially split the cost of the automobile).

Overlapping transportation segments can also be combined with multi-modal transportation proposal generation. For example, transportation segments utilizing additional modalities may be added before or after one or both of the overlapping transportation segments **550**, **572**. In particular, transportation segment **548** occurs before transportation segment **550** and includes a modality **552** of transportation by walking. The transportation segment **570** also occurs before the transportation segment **572** and includes a modality **573** of transportation by scooter. Specifically, the transportation segment **548** includes the transportation action **553** with an action **557** specifying that a first user associated with the transportation proposal **544** start walking from the location **556**. According to the transportation action **554**, the first user may walk along the route **558** according to the action **559** until arriving at the location **560**, at which point the user will stop walking as specified in the action **561** of the transportation action **555**. The transportation segment **570** also includes a transportation action **574** with an action **578** specifying that a second user associated with the transportation proposal **546** start riding a scooter from their starting location **577**. The second user may then ride the scooter along the route **579** according to the action **580** of the transportation action **575** until arriving at the location **560**, at which point the action **582** of the transportation action **576** specifies that the user will stop riding the scooter.

By performing the transportation segments **548**, **570** before their corresponding overlapping transportation segments **550**, **572**, the first and second users may be able to meet at the common pick-up location **560**. By adding additional transportation segments of other modalities, the transportation proposals **544**, **546** may extend the feasibility and benefits of sharing vehicles such as automobiles. For example, the first and second users may be too far apart to feasibly share an automobile to each of their destinations, but may be able to do so if they meet at the location **560** between their two respective starting locations **556**, **577**. The transportation proposals **544**, **546** may also be generated to account for the first and second users' preferences, available transportation modalities, and relative distances to the location **560**. For example, the first user may be located closer to the location **560** than the second user and may therefore be able to walk to the location **560** in the time it takes the second user to ride a scooter to the location **560**. In another example, the second user may be located near an available scooter, while there may be no such personal mobility vehicles located near the first user, so the second user may be able to scooter while the first user walks. Transportation proposals generated to account for such contextual and preference information may increase the efficiency of utilized transportation resources while also reducing costs and time spent in transportation for users.

FIG. **6** illustrates a method **600** according to an exemplary embodiment of the present disclosure. The method **600** may be performed to generate transportation proposals in response to received transportation requests. The method **600** may be performed by a computer system, such as the system **200**. For example, the method **600** may be performed by the server **202**, the user device **250**, the user database **260**, and/or the vehicle database **266**. The method **600** may also be implemented by a set of instructions stored on a computer readable medium that, when executed by a processor, cause the computer system to perform the method **600**. For example, all or part of the method **600** may be implemented by a CPU and/or memory of the server **202**, the user device **250**, the user database **260**, and/or the vehicle database **266**. Although the examples below are described with reference to the flowchart illustrated in FIG. **6**, many other methods of performing the acts associated with FIG. **6** may be used. For example, the order of some of the blocks may be changed, certain blocks may be combined with other blocks, one or more of the blocks may be repeated, and some of the blocks described may be optional.

The method **600** begins with receiving a transportation request (block **602**). For example, and referring to FIG. **2**, the server **202** may receive a transportation request **252** from a user device **250**. The transportation request **252** may specify a second location **256** (e.g., a destination location to which transportation is desired). In certain implementations, the transportation request **252** may also specify a first location **254** (e.g., an origin location from which transportation is desired). In other implementations, the server **202** may determine a first location **254**, for example based on a current location of the user device **250**. In certain implementations, the server **202** may receive the transportation request **252** from the user device **250** over a network connection, such as the Internet.

Referring again to FIG. **6**, a transportation proposal may be generated that identifies a transportation route between the first location and the second location (block **604**). Returning to FIG. **2**, the server **202** may generate a transportation proposal **204** in response to receiving the transportation request **252**. The transportation proposal **204** may be generated to identify a transportation route between the first location **254** and the second location **256**.

Referring again to FIG. **6**, to generate the transportation proposal, modalities available to satisfy the transportation request may be determined (block **606**). The modalities that are available may be determined according to modalities serviceable by the system. The modalities may include one or more of an automobile modality (e.g., transportation by

automobile), an autonomous automobile modality (e.g., transportation by autonomous automobile), a bus modality (e.g., transportation by bus), a train modality (e.g., transportation by train), a boat modality (e.g., transportation by boat), a ferry modality (e.g., transportation by ferry), a bike modality (e.g., transportation by docked or dockless bikes), a scooter modality (e.g., transportation by scooter) and a walking modality (e.g., transportation by walking). In certain implementations, the modalities that are available may be identified as modalities with corresponding vehicles located near the first and/or second locations **254**, **256** and/or located between the first and/or second locations **254**, **256**.

Transportation segments may be determined for the determine modalities and may be combined to form the transportation proposal (block **606**). The transportation segments may correspond to a portion of a transportation route between the first location **254** and the second location **256**. In particular, transportation segments may identify a portion of a transportation route between the first location **254** and the second location **256** that complies with one or more operational requirements of a corresponding modality. For example, scooters may have shorter range (e.g., may be capable of travelling shorter distances) than other types of vehicles (e.g., trains, buses, automobiles). Accordingly, a transportation segment corresponding to a scooter modality may be generated to cover a shorter portion of the route between the first location **254** and the second location **256**. In certain implementations, transportation segments corresponding to rideable modalities (e.g., a bike modality and/or a scooter modality) may be generated to be shorter than for other modalities. For example, the server **202** may determine a battery level of a rideable vehicle (e.g., an electrically powered and/or electrically assisted scooter and/or bike) and may generate a segment corresponding to the rideable modality based on the battery level of the rideable vehicle (e.g., to have a distance less than or equal to a range of the rideable vehicle determined based on the battery level).

The transportation segments for the modalities may be combined to form the transportation proposal. For example, the transportation segments may be combined to form a transportation route between the first location **254** and the second location **256**. The combined transportation segments may include transportation segments that specify more than one type of modality. For example, the combined transportation segments may include a first transportation segment corresponding to a rideable modality and a second transportation segment corresponding to a walking modality. In still further examples, the transportation segments may be assigned such that two or more of the transportation segments occur at least partially in parallel. For example, and referring to FIG. **3**B, the transportation segments **380**, **306** include modalities **330**, **350** assigned so that the transportation segments **380**, **306** occur at least partially in parallel. Transportation segments that occur at least partially in parallel may include an earlier transportation segment that begins before a later transportation segment and ends after the later transportation segment begins. For example, the transportation segment **380** begins with the user accessing the scooter before the transportation segment **306** begins and ends after the transportation segment **306** ends with the user stopping scootering at their final destination. In still further examples, as discussed in connection with FIGS. **4**A-**4**B, two or more of the combined transportation segments may include modalities specifying the same type of transportation. In particular, in certain instances, two or more adjacent transportation segments may include corresponding modalities specifying the same type of transportation.

In still further implementations, transportation proposals may be generated to include modalities that involve operation of an automobile by a user. For example, a transportation proposal may include a transportation segment corresponding to a user driving their personal vehicle or a rented vehicle to a designated parking location. Upon arriving at the parking location, and paying for parking as necessary, the user may proceed to a subsequent transportation segment corresponding to transportation by personal mobility vehicle. For example, after parking, the user may ride a scooter from the designated parking location to their final destination. The subsequent transportation segment may also involve transportation by automobile. For example, after parking, the user may be picked up in a different vehicle for transportation to their final destination.

In further implementations, when determining the modalities at block **606** and/or when determining the transportation segments at block **608**, one or more user profiles may be associated with at least one of the transportation segments, as discussed above in connection with a FIGS. **5**A and **5**B. In still further implementations, the transportation proposal may be generated to include at least one transportation segment that at least partially overlaps a transportation segment of another transportation proposal (e.g., a transportation proposal associated with a different user), as discussed above in connection with FIG. **5**C. For example, the server **202** may receive transportation requests from multiple users with at least partially overlapping routes (e.g., origin and/or destination locations near one another, destinations in similar directions from the origin locations). The server **202** may then identify a modality (e.g., transportation by shared automobile) that can service at least a portion of the overlapping routes. The server **202** may then generate a segment based on the modality that services the portion of the overlapping routes and may combine the transportation segment with other transportation segments to form transportation proposals for the multiple users.

Returning to FIG. **6**, the transportation proposal may be transmitted for display on a mobile device (block **610**). Referring to FIG. **2**, the server **202** may transmit the transportation proposal **204** to the user device **250**. The user device **250** may then receive and display the transportation proposal for selection by user. Upon selection, the user may be able to receive transportation as indicated by the transportation proposal **204**. In certain implementations, the server **202** may generate multiple transportation proposals in response to a received transportation request **252**. In such implementations, the transportation proposal **204** may be transmitted with additional transportation proposals to the user device **250**. Additional details regarding display of one or more transportation proposals by the mobile device are discussed further below in connection with FIG. **8**.

In certain implementations, when transmitting the transportation proposal to the mobile device, the server may consider user preferences. For example, where the transportation proposal is one of multiple transportation proposals, the transportation proposal may be recommended more highly if it complies with one or more user preferences associated with a user profile associated with the mobile device. In other implementations, a price or cost associated with the transportation proposal may be adjusted to account for one or more marketplace conditions. For example, where completion of the transportation proposal would result in a vehicle of a particular modality being relocated from a location of low demand to a location of high demand for the modality associated with the vehicle, a price or cost asso-

ciated with the transportation proposal may be reduced to encourage acceptance and/or performance of that transportation proposal.

FIG. **7** illustrates a method according to an exemplary embodiment of the present disclosure. The method **700** may be performed to determine modalities and/or transportation segments according to marketplace conditions. For example, all or part of the method **700** may be performed in order to at least partially implement blocks **606** and **608** of the method **600**. The method **700** may be performed by a computer system, such as the system **200**. For example, the method **700** may be performed by the server **202**, the user device **250**, the user database **260**, and/or the vehicle database **266**. The method **700** may also be implemented by a set of instructions stored on a computer-readable medium that, when executed by a processor, cause the computer system to perform the method **700**. For example, all or part of the method **700** may be implemented by a CPU and/or memory of the server **202**, the user device **250**, the user database **260**, and/or the vehicle database **266**. Although the examples below are described with reference to the flowchart illustrated in FIG. **7**, many other methods of performing the acts associated with FIG. **7** may be used. For example, the order of some of the blocks may be changed, certain blocks may be combined with other blocks, one or more of the blocks may be repeated, and some of the blocks described may be optional.

The method **700** begins with comparing locations of vehicles associated with a first modality to expected future request locations for transportation by vehicles of the first modality (block **702**). The comparison may be performed to determine whether a distribution of vehicles associated with the first modality differs from a distribution of expected requests for vehicles of the first modality. In particular, the comparison may determine whether there is a misalignment in locations of the vehicles with the distribution of expected requests for the vehicles. Referring to FIG. **2**, the locations of the vehicles may be identified using the vehicle database **266**. For example, the server **202** may compare vehicle locations **268** associated with the first modality in the vehicle database **266**. The locations of the vehicles may include current locations of the vehicles. For example, the current locations of vehicles associated with the first modality may be compared with expected future request locations for vehicles associated with the first modality in the near future (e.g., 10 minutes, 30 minutes). The locations of vehicles may also include predicted future locations of the vehicle. For example, predicted future locations of the vehicle may be compared to expected future request locations further into the future (e.g., 45 minutes, 1 hour). Certain implementations may compare both current and predicted future locations of vehicles.

The first modality may be selected from among a list of potential modalities. For examples, the first modality may be selected from among transportation by automobile, transportation by scooter, transportation by bike, transportation by train, and transportation by bus. In certain implementations, the first modality may be selected according to user preferences. For example, the first modality may be selected as a modality preferred by a user associated with a received transportation request. In certain implementations, the method **700** may be repeated for more than one modality (e.g., may be repeated for each of the list of modalities and/or for each of the modalities preferred by a user associated with the received transportation request).

Returning to FIG. **7**, a first vehicle associated with the first modality may then be identified that has a location that differs from expected future request locations (block **704**). The first vehicle may be identified based on a misalignment between the locations of vehicles associated with the first modality and expected requests for transportation by vehicles associated with the first modality. For example, the first vehicle may be identified as a vehicle currently located in an area of low demand for the first modality. In another example, the comparison may identify a vehicle that is expected to be located in an area of low demand for the first modality in the future (e.g., after fulfilling a transportation proposal). In a still further example, the comparison may identify a surplus of vehicles associated with the first modality in an area of comparatively low demand for the first modality. For example, there may be 20 scooters in an area that is only expected to receive requests for 10 scooters in the near future (e.g., in the next 30 minutes, one hour, two hours, four hours).

Returning to FIG. **7**, the first modality may be assigned as a corresponding modality of a transportation segment (block **706**). For example, the first modality may be identified as a modality for which a transportation segment is to be determined at block **608**. In certain instances, the transportation segment determined for the first modality may depend on whether the first vehicle was identified based on a current location of the first vehicle or a predicted location of the first vehicle. For example, the first modality may be assigned to an earlier transportation segment if the first modality is identified based on the current location of the first vehicle. As another example, the first modality may be assigned to a later transportation segment if the first modality is identified based on a predicted future location of the first vehicle. In this way, the server **202** may be better able to account for current marketplace conditions while also taking into consideration and preemptively resolving future marketplace conditions.

The first vehicle may also be assigned to service the transportation segment (block **708**). For example, and referring to FIG. **2**, the transportation segments **206**, **224**, **236** may store an indication of a vehicle **210**, **228**, **240** assigned to service the transportation segments **206**, **224**, **236**. In such examples, to assign the first vehicle to the transportation segment **206**, **224**, **236**, an indication of the first vehicle may be stored with the transportation segment. By assigning the vehicle, the method **700** may enable generated transportation proposals to directly address misalignments of vehicle locations with marketplace conditions. In particular, where the transportation segment to which the first vehicle is assigned occurs in the near future, fulfillment of the transportation segment may leave the first vehicle in an area of high demand, at least partially remedying the vehicle location misalignment.

In certain implementations, however, the block **708** may be optional. For example, where the transportation segment to which the first modality is assigned occurs too far in the future (e.g., 10 minutes in the future, 30 minutes in the future), it may not be practicable to assign specific vehicles to transportation segments when initially generating the transportation proposal. Accordingly, for such transportation segments, the method **700** may stop processing after assigning the first modality to the transportation segment at block **706**.

FIG. **8** illustrates user interfaces **800**A-D according to exemplary embodiments of the present disclosure. The user interfaces **800**A-D may be implemented by a mobile device and/or a user device to display one or more transportation proposals received by the mobile device and/or user devices (e.g., transportation proposals from a current location to an

ending location). For example, the user interfaces **800**A-D may be used to at least partially implement block **610** of the method **600**. User interfaces **800**A-C include maps **802**A-C that depict at least a part of a transportation route between two locations (e.g., an origin location and a destination location). For example, the maps **802**A-C may depict a transportation route corresponding to a selected transportation proposal (e.g., the transportation proposal **806**A-C). After receiving one or more transportation proposals, the user device may split the transportation proposals into one or more groups. For example, the user interface **800**A depicts multiple transportation proposals **806**A, **810**A, **812**. These proposals are separated into two groups: recommended proposals **804**A and alternative options **805**. The user interface **800**A splits these groups into a vertical list, but other implementations may also be utilized. For example, the user interfaces **800**B-C separate transportation proposals **806**B-C, **810**B-C into groups **804**B-C selected above the transportation proposals **806**B-C, **810**B-C. In either instance, further transportation proposals may be viewable by scrolling down using the user interfaces **800**A-C. For example, the user interface **800** D depicts multiple transportation proposals **816**, **820**, **822**, **824**. These transportation proposals **816**, **820**, **822**, **824** are organized into further categories **814**, **818** similar to the categories **804**A, **805** of the user interface **800**A. The transportation proposals **816**, **820**, **822**, **824** may be viewable by scrolling down from a main screen, such as one of the interfaces depicted by user interfaces **800**A-C. The user interface **800**D further includes additional categories **826** selectable at the top of the interface.

Displaying the transportation proposals **806**A-C, **810**A-C, **812**, **816**, **820**, **822**, **824** may cause the mobile device to display one or more of the modalities included within the transportation proposal. For example, for depicted proposals, the mobile device may depict a visual indication of the modalities included in the proposal (e.g., a textual, pictorial depiction). The mobile device may also depict further details regarding the modalities, such as a time spent using each modality, a distance covered by each modality, and/or a vehicle (e.g., a train or bus line) used in connection with each modality. For example, the user interfaces **800**A-C depict indicators **808**A-C for the transportation proposals **806**A-C. The indicators **808**A-C take different forms. For example, the indicators **808**A include pictorial and textual representations of the included modalities and the time spent with each modality. In particular, the indicators **808**A depicts a bicycle pictorial along with the number "7", indicating that the transportation proposal **806** *a* includes a bike modality that is expected to last seven minutes. The indicators **808**A also depict a vehicle identifier "K/T" identifying the K/T train line along with the number "24", indicating that the transportation proposal **806** *a* includes a train modality that is expected to last 24 minutes. The indicators **808**A also includes two walking pictorials, indicating that the transportation proposal **806**A includes two walking modalities. As depicted, the pictorials are arranged in the order they will occur in the transportation proposal. The user interface **800**B similarly includes textual identifiers of the "N" and "K/T" train lines, along with a visual bike identifier beneath the textual identifiers of the train lines. The indicators **808**C of the user interface **800** C include walking, biking, and train pictorials beneath a summary title of the transportation proposal **806**C. Further, in addition to pictorial identifiers of the modalities, the depicted transportation proposals **816**, **820**, **822**, **824** of the user interface **800**D include more complete textual identifiers of certain modalities (e.g., modalities other than walking modalities). The additional information may include complete train line names, transit stop identifiers, and/or may identify a type of automobile transportation received (e.g., shared transportation with other users and/or standard transportation not associated with other users requesting transportation). In certain implementations, the indicators **808**A-C may be selectable. For instance, the indicators **808**A-C may be selectable to enable a user to change one of the modalities for the transportation proposal **806**A-C. In such instances, when a user selects an indicator **808**A-C, a menu (e.g., a drop-down or other selectable menu) may appear, enabling the user to select between alternative modalities for use with a particular segment (e.g., based on other transportation proposals or segments identified or generated in response to a received transportation request. In one example, a user may select an indicator **808**A-C corresponding to a scooter modality and select, via the menu, to replace the scooter modality with a bike modality for the segment. In another example, a user may select an indicator corresponding to a train modality and may select, via the menu, to replace the train modality with an automobile modality. In still further examples, the user may select an indicator **808**A-C corresponding to a modality to remove the modality from the transportation proposal **806**A-C. For example, the user may select an indicator corresponding to a scooter modality that is followed by an automobile modality in the transportation proposal **806**A-C and may, via the menu, remove the scooter modality from the transportation proposal **806**A-C. In such examples, the other modalities of the transportation proposal **806**A-C may be adjusted to compensate for the removed modality (e.g., the automobile modality may be lengthened to replace the scooter modality).

In each instance, the user interfaces **800**A-D depict the modalities of the transportation proposals **806**A-C, **810**A-C, **812**, **816**, **820**, **822**, **824** in a compact and concise manner without unduly restricting the amount of visible information. Such a system for display can enable greater selection and visibility of potential transportation proposal options by reducing the total screen space required to display each transportation proposal. Further, such compact and concise depictions may allow a user to more quickly review and evaluate the potential transportation options, including transportation proposals that utilize different types of transportation.

FIG. **9** depicts an example computer system **900** that may be revised to implement one or more of the devices and/or components of FIG. **1**A and/or FIG. **2**, such as the transportation matching system **102**, the server **202**, the user device **250**, the user database **260**, and/or the vehicle database **266**. In particular embodiments, one or more computer systems **900** perform one or more steps of one or more methods described or illustrated herein. In particular embodiments, one or more computer systems **900** provide the functionalities described or illustrated herein. In particular embodiments, software running on one or more computer systems **900** performs one or more steps of one or more methods described or illustrated herein or provides the functionalities described or illustrated herein. Particular embodiments include one or more portions of one or more computer systems **900**. Herein, a reference to a computer system may encompass a computing device, and vice versa, where appropriate. Moreover, a reference to a computer system may encompass one or more computer systems, where appropriate.

This disclosure contemplates any suitable number of computer systems **900**. This disclosure contemplates the computer system **900** taking any suitable physical form. As

example and not by way of limitation, the computer system **900** may be an embedded computer system, a system-on-chip (SOC), a single-board computer system (SBC) (such as, for example, a computer-on-module (COM) or system-on-module (SOM)), a desktop computer system, a laptop or notebook computer system, an interactive kiosk, a mainframe, a mesh of computer systems, a mobile telephone, a personal digital assistant (PDA), a server, a tablet computer system, an augmented/virtual reality device, or a combination of two or more of these. Where appropriate, the computer system **900** may include one or more computer systems **900**; be unitary or distributed; span multiple locations; span multiple machines; span multiple data centers; or reside in a cloud, which may include one or more cloud components in one or more networks. Where appropriate, one or more computer systems **900** may perform without substantial spatial or temporal limitation one or more steps of one or more methods described or illustrated herein. As an example and not by way of limitation, one or more computer systems **900** may perform in real time or in batch mode one or more steps of one or more methods described or illustrated herein. One or more computer systems **900** may perform at different times or at different locations one or more steps of one or more methods described or illustrated herein, where appropriate.

In particular embodiments, computer system **900** includes a processor **906**, memory **904**, storage **908**, an input/output (I/O) interface **910**, and a communication interface **912**. Although this disclosure describes and illustrates a particular computer system having a particular number of particular components in a particular arrangement, this disclosure contemplates any suitable computer system having any suitable number of any suitable components in any suitable arrangement.

In particular embodiments, processor **906** includes hardware for executing instructions, such as those making up a computer program. As an example and not by way of limitation, to execute instructions, processor **906** may retrieve (or fetch) the instructions from an internal register, an internal cache, memory **904**, or storage **908**; decode and execute the instructions; and then write one or more results to an internal register, internal cache, memory **904**, or storage **908**. In particular embodiments, processor **906** may include one or more internal caches for data, instructions, or addresses. This disclosure contemplates processor **906** including any suitable number of any suitable internal caches, where appropriate. As an example and not by way of limitation, processor **906** may include one or more instruction caches, one or more data caches, and one or more translation lookaside buffers (TLBs). Instructions in the instruction caches may be copies of instructions in memory **904** or storage **908**, and the instruction caches may speed up retrieval of those instructions by processor **906**. Data in the data caches may be copies of data in memory **904** or storage **908** that are to be operated on by computer instructions; the results of previous instructions executed by processor **906** that are accessible to subsequent instructions or for writing to memory **904** or storage **908**; or any other suitable data. The data caches may speed up read or write operations by processor **906**. The TLBs may speed up virtual-address translation for processor **906**. In particular embodiments, processor **906** may include one or more internal registers for data, instructions, or addresses. This disclosure contemplates processor **906** including any suitable number of any suitable internal registers, where appropriate. Where appropriate, processor **906** may include one or more arithmetic logic units (ALUs), be a multi-core processor, or include one or more processors **906**. Although this disclosure describes and illustrates a particular processor, this disclosure contemplates any suitable processor.

In particular embodiments, memory **904** includes main memory for storing instructions for processor **906** to execute or data for processor **906** to operate on. As an example, and not by way of limitation, computer system **900** may load instructions from storage **908** or another source (such as another computer system **900**) to memory **904**. The processor **906** may then load the instructions from memory **904** to an internal register or internal cache. To execute the instructions, the processor **906** may retrieve the instructions from the internal register or internal cache and decode them. During or after execution of the instructions, the processor **906** may write one or more results (which may be intermediate or final results) to the internal register or internal cache. The processor **906** may then write one or more of those results to the memory **904**. In particular embodiments, the processor **906** executes only instructions in one or more internal registers or internal caches or in memory **904** (as opposed to storage **908** or elsewhere) and operates only on data in one or more internal registers or internal caches or in memory **904** (as opposed to storage **908** or elsewhere). One or more memory buses (which may each include an address bus and a data bus) may couple the processor **906** to the memory **904**. The bus may include one or more memory buses, as described in further detail below. In particular embodiments, one or more memory management units (MMUs) reside between the processor **906** and memory **904** and facilitate accesses to the memory **904** requested by the processor **906**. In particular embodiments, the memory **904** includes random access memory (RAM). This RAM may be volatile memory, where appropriate. Where appropriate, this RAM may be dynamic RAM (DRAM) or static RAM (SRAM). Moreover, where appropriate, this RAM may be single-ported or multi-ported RAM. This disclosure contemplates any suitable RAM. Memory **904** may include one or more memories **904**, where appropriate. Although this disclosure describes and illustrates particular memory, this disclosure contemplates any suitable memory.

In particular embodiments, the storage **908** includes mass storage for data or instructions. As an example and not by way of limitation, the storage **908** may include a hard disk drive (HDD), a floppy disk drive, flash memory, an optical disc, a magneto-optical disc, magnetic tape, or a Universal Serial Bus (USB) drive or a combination of two or more of these. The storage **908** may include removable or non-removable (or fixed) media, where appropriate. The storage **908** may be internal or external to computer system **900**, where appropriate. In particular embodiments, the storage **908** is non-volatile, solid-state memory. In particular embodiments, the storage **908** includes read-only memory (ROM). Where appropriate, this ROM may be mask-programmed ROM, programmable ROM (PROM), erasable PROM (EPROM), electrically erasable PROM (EEPROM), electrically alterable ROM (EAROM), or flash memory or a combination of two or more of these. This disclosure contemplates mass storage **908** taking any suitable physical form. The storage **908** may include one or more storage control units facilitating communication between processor **906** and storage **908**, where appropriate. Where appropriate, the storage **908** may include one or more storages **908**. Although this disclosure describes and illustrates particular storage, this disclosure contemplates any suitable storage.

In particular embodiments, the I/O Interface **910** includes hardware, software, or both, providing one or more interfaces for communication between computer system **900** and

one or more I/O devices. The computer system **900** may include one or more of these I/O devices, where appropriate. One or more of these I/O devices may enable communication between a person and computer system **900**. As an example and not by way of limitation, an I/O device may include a keyboard, keypad, microphone, monitor, screen, display panel, mouse, printer, scanner, speaker, still camera, stylus, tablet, touch screen, trackball, video camera, another suitable I/O device or a combination of two or more of these. An I/O device may include one or more sensors. Where appropriate, the I/O interface **910** may include one or more device or software drivers enabling processor **906** to drive one or more of these I/O devices. The I/O interface **910** may include one or more I/O interfaces **910**, where appropriate. Although this disclosure describes and illustrates a particular I/O interface, this disclosure contemplates any suitable I/O interface or combination of I/O interfaces.

In particular embodiments, communication interface **912** includes hardware, software, or both providing one or more interfaces for communication (such as, for example, packet-based communication) between computer system **900** and one or more other computer systems **900** or one or more networks **914**. As an example and not by way of limitation, communication interface **912** may include a network interface controller (NIC) or network adapter for communicating with an Ethernet or any other wire-based network or a wireless NIC (WNIC) or wireless adapter for communicating with a wireless network, such as a Wi-Fi network. This disclosure contemplates any suitable network **914** and any suitable communication interface **912** for the network **914**. As an example and not by way of limitation, the network **914** may include one or more of an ad hoc network, a personal area network (PAN), a local area network (LAN), a wide area network (WAN), a metropolitan area network (MAN), or one or more portions of the Internet or a combination of two or more of these. One or more portions of one or more of these networks may be wired or wireless. As an example, computer system **900** may communicate with a wireless PAN (WPAN) (such as, for example, a Bluetooth® WPAN), a WI-FI network, a WI-MAX network, a cellular telephone network (such as, for example, a Global System for Mobile Communications (GSM) network), or any other suitable wireless network or a combination of two or more of these. Computer system **900** may include any suitable communication interface **912** for any of these networks, where appropriate. Communication interface **912** may include one or more communication interfaces **912**, where appropriate. Although this disclosure describes and illustrates a particular communication interface, this disclosure contemplates any suitable communication interface.

The computer system **900** may also include a bus. The bus may include hardware, software, or both and may communicatively couple the components of the computer system **900** to each other. As an example and not by way of limitation, the bus may include an Accelerated Graphics Port (AGP) or any other graphics bus, an Enhanced Industry Standard Architecture (EISA) bus, a front-side bus (FSB), a HYPERTRANSPORT (HT) interconnect, an Industry Standard Architecture (ISA) bus, an INFINIBAND interconnect, a low-pin-count (LPC) bus, a memory bus, a Micro Channel Architecture (MCA) bus, a Peripheral Component Interconnect (PCI) bus, a PCI-Express (PCIe) bus, a serial advanced technology attachment (SATA) bus, a Video Electronics Standards Association local (VLB) bus, or another suitable bus or a combination of two or more of these. The bus may include one or more buses, where appropriate. Although this disclosure describes and illustrates a particular bus, this disclosure contemplates any suitable bus or interconnect.

Herein, a computer-readable non-transitory storage medium or media may include one or more semiconductor-based or other types of integrated circuits (ICs) (e.g., field-programmable gate arrays (FPGAs) or application-specific ICs (ASICs)), hard disk drives (HDDs), hybrid hard drives (HHDs), optical discs, optical disc drives (ODDs), magneto-optical discs, magneto-optical drives, floppy diskettes, floppy disk drives (FDDs), magnetic tapes, solid-state drives (SSDs), RAM-drives, SECURE DIGITAL cards or drives, any other suitable computer-readable non-transitory storage media, or any suitable combination of two or more of these, where appropriate. A computer-readable non-transitory storage medium may be volatile, non-volatile, or a combination of volatile and non-volatile, where appropriate.

Herein, "or" is inclusive and not exclusive, unless expressly indicated otherwise or indicated otherwise by context. Therefore, herein, "A or B" means "A, B, or both," unless expressly indicated otherwise or indicated otherwise by context. Moreover, "and" is both joint and several, unless expressly indicated otherwise or indicated otherwise by context. Therefore, herein, "A and B" means "A and B, jointly or severally," unless expressly indicated otherwise or indicated otherwise by context.

The scope of this disclosure encompasses all changes, substitutions, variations, alterations, and modifications to the example embodiments described or illustrated herein that a person having ordinary skill in the art would comprehend. The scope of this disclosure is not limited to the example embodiments described or illustrated herein. Moreover, although this disclosure describes and illustrates respective embodiments herein as including particular components, elements, feature, functions, operations, or steps, any of these embodiments may include any combination or permutation of any of the components, elements, features, functions, operations, or steps described or illustrated anywhere herein that a person having ordinary skill in the art would comprehend. Furthermore, reference in the appended claims to an apparatus or system or a component of an apparatus or system being adapted to, arranged to, capable of, configured to, enabled to, operable to, or operative to perform a particular function encompasses that apparatus, system, component, whether or not it or that particular function is activated, turned on, or unlocked, as long as that apparatus, system, or component is so adapted, arranged, capable, configured, enabled, operable, or operative. Additionally, although this disclosure describes or illustrates particular embodiments as providing particular advantages, particular embodiments may provide none, some, or all of these advantages.

Example methods and systems are described herein. Any example embodiment or feature described herein is not necessarily to be construed as preferred or advantageous over other embodiments or features. The example embodiments described herein are not meant to be limiting. It will be readily understood that certain aspects of the disclosed systems and methods can be arranged and combined in a wide variety of different configurations, all of which are contemplated herein.

Furthermore, the particular arrangements shown in the Figures should not be viewed as limiting. It should be understood that other embodiments may include more or less of each element shown in a given Figure. Further, some of the illustrated elements may be combined or omitted. Yet further, an example embodiment may include elements that are not illustrated in the Figures.

The invention claimed is:

1. A system comprising:

a processor; and

a memory storing instructions which, when executed by the processor, cause the processor to:

receive, from a computing device, a request for transportation;

determine at least two modalities to fulfill the request for transportation;

determine a route including the at least two modalities, wherein the route includes a first segment associated with a first vehicle associated with at least one of the at least two modalities, the first segment including an ending location selected based on a range of the first vehicle; and

send the route to the computing device for display on the computing device.

2. The system of claim **1**, wherein the first segment is associated with a rideable modality, and wherein the route includes a second segment associated with a walking modality, and wherein the first segment is longer than the second segment.

3. The system of claim **1**, wherein the first vehicle includes at least one of a bike and a scooter.

4. The system of claim **2**, wherein the route further includes a third segment associated with a second vehicle, wherein the first segment occurs at least partially in parallel with the third segment such that the first vehicle is transported by the second vehicle.

5. The system of claim **2**, wherein determining the route comprises:

determining a range of the first vehicle based on a battery level of the first vehicle; and

determining the ending location of the first segment such that the first segment has a distance less than or equal to the range of the first vehicle.

6. The system of claim **1**, wherein the route is determined according to a user preference specifying at least one of: (i) at least one preferred modality, (ii) a route preference, (iii) a travel time preference, (iv) a cost preference, (v) a health preference, and (vi) an environmental preference.

7. The system of claim **1**, wherein the computing device displays at least a visual indication of the at least two modalities.

8. A method comprising:

receiving, from a computing device, a request for transportation;

determining at least two modalities to fulfill the request for transportation;

determining a route including the at least two modalities, wherein the route includes a first segment associated with a first vehicle associated with at least one of the at least two modalities, the first segment including an ending location selected based on a range of the first vehicle; and

sending the route to the computing device for display on the computing device.

9. The method of claim **8**, wherein the first segment is associated with a rideable modality, and wherein the route includes a second segment associated with a walking modality, and wherein the first segment is longer than the second segment.

10. The method of claim **8** wherein the first vehicle includes at least one of a bike and a scooter.

11. The method of claim **9**, wherein the route further includes a third segment associated with a second vehicle, wherein the first segment occurs at least partially in parallel with the third segment such that the first vehicle is transported by the second vehicle.

12. The method of claim **9**, wherein determining the route comprises:

determining a range of the first vehicle based on a battery level of the first vehicle; and

determining the ending location of the first segment such that the first segment has a distance less than or equal to the range of the first vehicle.

13. The method of claim **8**, wherein the route is determined based on a user preference specifying at least one of: (i) at least one preferred modality, (ii) a route preference, (iii) a travel time preference, (iv) a cost preference, (v) a health preference, and (vi) an environmental preference.

14. The method of claim **8**, wherein the computing device displays at least a visual indication of the at least two modalities.

15. A non-transitory, computer-readable medium storing instructions which, when executed by a processor, cause the processor to:

receive, from a computing device, a request for transportation;

determine at least two modalities to fulfill the request for transportation;

determine a route including the at least two modalities, wherein the route includes a first segment associated with a first vehicle associated with at least one of the at least two modalities, the first segment including an ending location selected based on a range of the first vehicle; and

send the route to the computing device for display on the computing device.

16. The non-transitory, computer-readable medium of claim **15**, wherein the first segment is associated with a rideable modality, and wherein the route includes a second segment associated with a walking modality, and wherein the first segment is longer than the second segment.

17. The non-transitory, computer-readable medium of claim **15**, wherein the first vehicle includes at least one of a bike and a scooter.

18. The non-transitory, computer-readable medium of claim **16**, wherein the route further includes a third segment associated with a second vehicle, wherein the first segment occurs at least partially in parallel with the third segment such that the first vehicle is transported by the second vehicle.

19. The non-transitory, computer-readable medium of claim **16**, wherein determining the route comprises:

determining a range of the first vehicle based on a battery level of the first vehicle; and

determining the ending location of the first segment such that the first segment has a distance less than or equal to the range of the first vehicle.

20. The non-transitory, computer-readable medium of claim **15**, wherein the route is determined according to a user preference specifying at least one of: (i) at least one preferred modality, (ii) a route preference, (iii) a travel time preference, (iv) a cost preference, (v) a health preference, and (vi) an environmental preference.

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